Chilton Publication

JANUARY, 1960

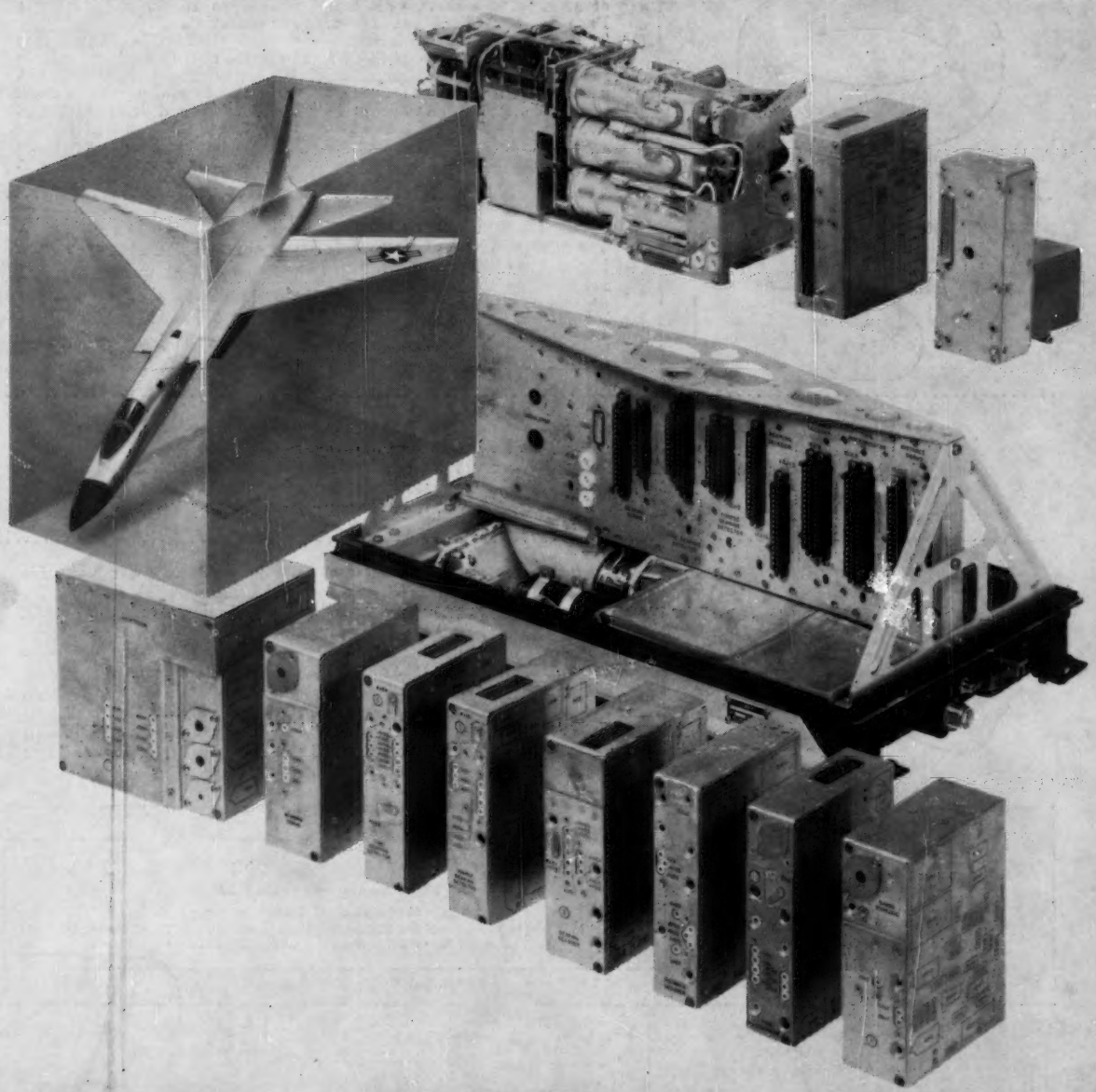
AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

Hydrogen Rocket Design Problems Revealed...P 32

"THROW-AWAY" ELECTRONICS—A NEW CONCEPT . . . P 24

Vigilante's Electronics—Integrated Modules . . . P 10 ↓



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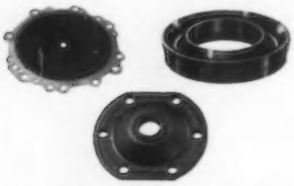

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January, 1960 *Volume 3, Number 1*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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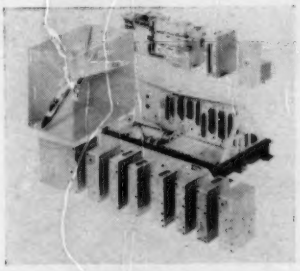
THE COVER STORY

Use of the modular concept in the electronic system of A3J Vigilante results in what designer Collins Radio Co. calls an "Integrated Electronic System." Entire (UHF, TACAN, SIF, and ADF) system is housed in five "black boxes" mounted on a single rack. Modules shown on the cover are the innards of one of these "black boxes". See page 15.



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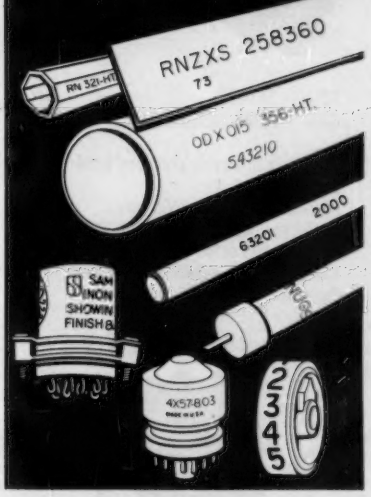

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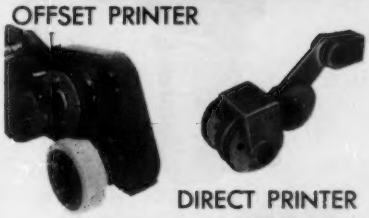

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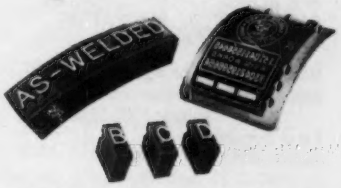

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Circle 6 on Inquiry Card

EDITORIAL

The Hollow Bomber— End of Versatile Airpower?

Now, the Administration is giving the Air Force a shell, called the B-70, that will do Mach 3 in a few years. A shell is all, since the significant 'guts' of the ship are being left out.

Technically called a stretch-out of funding, it's a lot more than that. The B-70's rubber band has been snapped.

Remember the old adage, "He who fights and runs away, lives to fight another day"? B-70 can just run away. It hasn't the 'guts' to fight with.

Sure, propaganda-wise, we will have an air-frame capable of skittering along at Mach 3. But, the electronic countermeasure system, and the inertial navigation and bombing system won't be there to deliver the punch.

Are we vulnerable? Let's go all the way. Build the Maginot line of hard missile bases. Spend lots of money running 50 mph railroads for mobile launch sites. Rely 100 per cent on missiles with very low reliability. Produce missiles capable of destroying a target only when equipped with a hydrogen warhead. Forget versatility in air power. Then, agree to a ban on nuclear warfare with all countries of the world.

That's all we need. Russia is working on a Mach 3 aircraft, the nuclear-powered bomber, and a host of other projects to make its air force the most technically advanced and powerful in the world. We cancel the F-108, stretch out the B-70.

The cutbacks are putting us in a box. Let's hope no one closes the lid.

Tom MacNew
Editor

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17,000	3"	225°F	Air Oil Mist	2-3PSI
37,500	1"	650°F	Mil-O-5606	20-30PSI
13,800	1 11/16"	—300°F	LOX	50PSI
3,500	1⅜"	270°F	Acetone, H2S04 and Phenol	80PSI
1,750	1⅞"	100°F	Mercury with 5% water	160PSI
173	1"	210°F	Tomato products	30PSI
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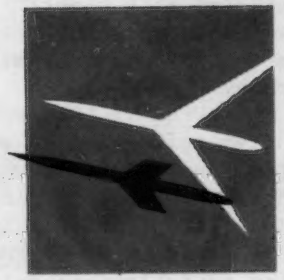


SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES.

MISSILES AND SPACE VEHICLES

Design

THE MERCURY SPACE CAPSULE will have X-ray sensors to give early warning of solar flare outbursts. Same outbursts which cause deadly corpuscular radiation also emit X-rays, which arrive here at least several hours before the radiation. Water or liquid hydrogen would shield against the harmful radiation emittance, which resembles cosmic rays. Intensity reached an estimated 1000 Roentgens per hour during solar flares.

GROWING U. S. DYNA SOAR EFFORT reflects possible military implications of our own boost-glide research. Maneuverability of an orbital bomber would depend on complete knowledge of lift/drag relationships from landing velocities to about 18,000 mph. Dyna Soar's glide vehicle will reportedly be controlled by jets--resembling the X-15's hydrogen peroxide system--and aerodynamic controls. Ion propulsion systems for boost-glide applications are believed under development.

REUSABLE BOOSTER with small wings and separate powerplant has been proposed by two Convair engineers. Instead of being jettisoned, booster would be flown back under human piloting.

ILL-FATED ATLAS ABLE IV carried a payload with solar cell paddlewheels, and a new Space Technology Lab engine which has been called a fourth stage. Two thrust chambers--one at each pole of satellite--were linked to a tank of hydrazine propellant. Spontaneous ignition would have taken place when hydrazine flowed across aluminum oxide near the throat of the rocket nozzles. Base chamber would increase satellite velocity. Top chamber would reverse thrust near the moon.

VEGA CANCELLATION came because other rocket vehicles could carry three ton satellites into orbit. It was the first new system developed from the beginning for space. Delivery was expected by early next year.

Development

ARMY TACTICAL NEEDS are leading to accelerated development of Missile A, a solid propellant, direct-support weapon, and Missile B, for general support to infantry division.

NEW MANAGEMENT SETUP of ARDC now has a Control Systems Group responsible for electronic aspects of weapon system development. Command and control systems receive equal emphasis with ballistic missile and aeronautical systems.

ABLATION HEAT SHIELDS for Mercury capsules are being produced by Cincinnati Testing Labs. Shield is about one inch thick with spherical radius of 80 in. It weighs over 300 lb. A general Electric-B. F. Goodrich team, and the Durez Plastics Div. of Hooker Chemical Corp., provided ablation shields for test shots.

LUNIK III TRAJECTORY has been traced back to exact cutoff position and time, providing a clue to launching site. General Electric's Aero sciences Lab made the computer study.

SHRINKAGE PROBLEMS are occurring with MK 3 ablation heat shields at low temperature. Problem was first encountered on Haveg-manufactured shields. Attempted "fix" will be to vary post-cure cycle on shields produced by all subcontractors.

NEW NASA UNIT managing development and launching of Saturn, Nova and other space rockets is under Air Force Maj. Gen. Don Ostrander.

ELECTRONIC PROBLEMS forcing postponement of Thor Able shot at Venus

occurred with powerful transmitting device in payload. Device was developed to transmit from 50-million miles in space.

SUPER TALOS development as an anti-missile-missile was rumored because of a classified study by Navy's BuOrd (now BuWeapons) to find which missiles have such potential.

GYRO DRIFT DETECTION and compensation in sub's inertial navigation system is big problem in putting a Polaris on target. Sub must come up for LORAN and celestial checks to recalibrate gyros. The gyros have 1/100°F temp stabilization.

Production

MERGER of Navy's Bureau of Ordnance and Bureau of Aeronautics into the new Bureau of Naval Weapons may shorten weapon time between drawing-board and production through revised procedures.

SOON AVAILABLE: world-wide machine tool study made by Metalworking Equipment Div. of the Dept. of Commerce.

IMPROVED BULLPUP with prepackaged liquid motor is now in production at Martin-Orlando.

Procurement

ALL CONTRACTORS and suppliers for defense, atomic energy and space programs must now mark purchase orders with their program identification. Defense Materials System (DMS) Regulation No. 1 represents first general revision in the priority system for purchasing materials.

FIRMS HOLDING PRIME CONTRACTS over $1-million must now use Defense Small Business Subcontracting Program on related subcontracts.

AIRCRAFT

Design

SUPERSONIC VTOL FIGHTER is reportedly high in Air Force plans. Designs are expected to be submitted before March.

NEWEST LOCKHEED ELECTRAS have 13½-ft. rounded-tip Hamilton Standard props.

NORTH AMERICAN T2J-1 TRAINERS are being flown with the new Westinghouse J34-WE-48 jet engine featuring a single-stage turbine instead of the two-stage one in earlier J34 models.

T53-L-1 ENGINE on H-43B incorporates a vaporizing fuel injection system in the combuster. This allows stable operation at twice the engine's design altitude.

Development

TILTING, ANTI-FATIGUE PILOT SEAT has been flight tested for 80-hr 36 min. Cushion remains inflated for 20 sec, then is deflated for 20 sec. Pneumatic backrest can be inflated or deflated at pilot's discretion.

FATE OF THE B-70 is seriously clouded through Air Force decision to reduce spending on it to about $75-million next fiscal year. Target is now two test planes with decision deferred on further production.

Production

NAVY MAINTENANCE OFFICERS for future McDonnell F4H and North American A3J squadrons will be trained in the contractor plant. Only 49 per cent of Naval aircraft can be counted on as available for flight at one time. Rest are down for maintenance, supply or other reasons. Training specialists is aimed at keeping more aircraft in "up" status.

BEECH AIRCRAFT is producing two new business aircraft for 1960 sale. They are the six passenger Model 65 Queen Air--$120,000--and the single engine Model 33 Debonair--$19,995.

UMBAUGH AIRCRAFT plans to sell 12,000 two-place, rotary-wing Umbaugh 18's during 1960-61. Fairchild Engine and Airplane has the production subcontract.

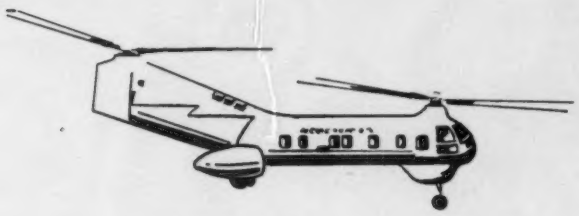
CESSNA reports current T-37B production is 15 per month. It plans to produce four 210's daily in January.

FIRST B-58 classed as operational joined SAC last month.

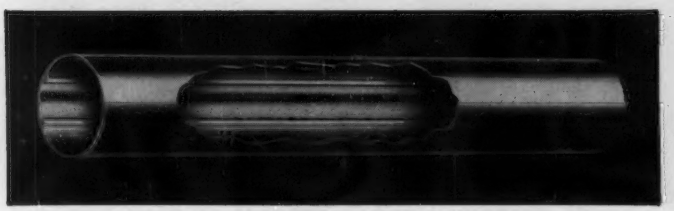
DOUGLAS A3D-2Q, for electronic reconnaissance, is entering Navy service.

Procurement

ORDERS from military agencies represent about 80 per cent of the business of aircraft producers, according to the latest Department of Commerce survey. Total backlog for complete aircraft, aircraft engines, and aircraft propellers amounted to over $12-million at the end of the third quarter of this year.



more and more— "impossible" tubular parts are fewer and fewer



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NORTH AMERICAN'S A3J Vigilante is shown with ground support and checkout equipment. Aircraft's systems are designed for easy service.

First Look at Systems Design in A3J Vigilante

Reliability Planning Pressed Deep Into Subcontractor Tiers; Hydraulic and Electrical Power Are Backbone of Entire Weapon System; Duality Within Systems Promotes Safety, Intersystem Functions Promote Efficiency

by John P. Kushnerick

The stage was set for the design of an aircraft that was to become known as the A3J Vigilante. Navy had made known that operational support costs for weapon systems had surpassed initial procurement costs. Aircraft "down time" was keeping one out of every three jets on the carrier hangar-deck. This meant simply that if the trend continued, three aircraft carriers would be required to do the job of two.

North American Aviation (NAA) took charge as weapon system manager on the multi-jet attack project with one concept in mind; only through reliability-planning could support costs, and down-time be reduced. NAA pressed deep into its subcontractor tiers the thought that reliability begins in preliminary design. As a result, NAA believes it has in the Vigilante a "package" that could not have been achieved without the weapon system management concept.

General Systems Design

The versatile Vigilante is a twin jet, all weather attack aircraft designed for carrier based operations. Powered by two J-79-GE-2 engines, it has Mach 2, high-altitude run-in potential for delivering nuclear weapons; or, low-level capabilities for tactical missions. Variable inlet ducts give optimum air flow and pressure to the engines through the aircraft's speed range.

A two-man crew sits in tandem under separate pneumatically-operated, clam shell canopies. Wing sections, vertical tail, and radome can be folded to reduce storage space on carrier decks. Wing is mounted high on the fuselage and sweeps back at 37.5 deg; horizontal tail sweepback is 45 deg.

Uncommon materials of construction are used widely in the aircraft structure. Lithium-bearing X-2020 aluminum alloy, hot-work H-11 tool steel, USS STRUX and gold-coated titanium are examples. Honeycomb sandwich is common in trailing edge areas. Integrally stiffened skins, both chemically and machined milled are used.

Flight controls are hydraulically powered and electronically controlled. Horizontal and vertical tail surfaces are all-moveable slabs. Lateral controls consist of three spoiler-deflectors on each wing. Lateral trim is effected by differential adjustment of the horizontal tail slabs. Pitch and yaw trim are conventional.

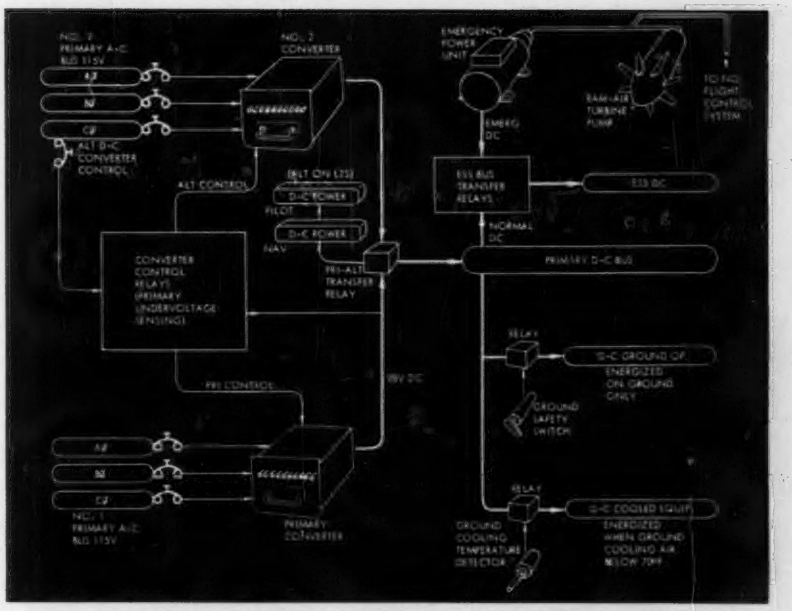
An automatic flight control system (AFCS) is incorporated for autonavigation, and LABS delivery of the bomb load. It is the "granddaddy" of the automatic pilot.

Boundary layer control (BLC) is used to facilitate airflow over the flaps on take-off and landing. High-pressure air begins to bleed from the engines when flaps are extended 7 deg. At 50 deg deflection, bleed air is maximum. Bleed air is fed through a continuous slot along the upper leading edge of both flaps.

"Droop snoot" leading edges, three sections per wing, are also used for better control at slow flight speeds. Each section uses an hydraulic motor, a gear-box, flexible drives, jacks screws, and a servo valve. The "droop" is hence hydraulically powered and electrically controlled.

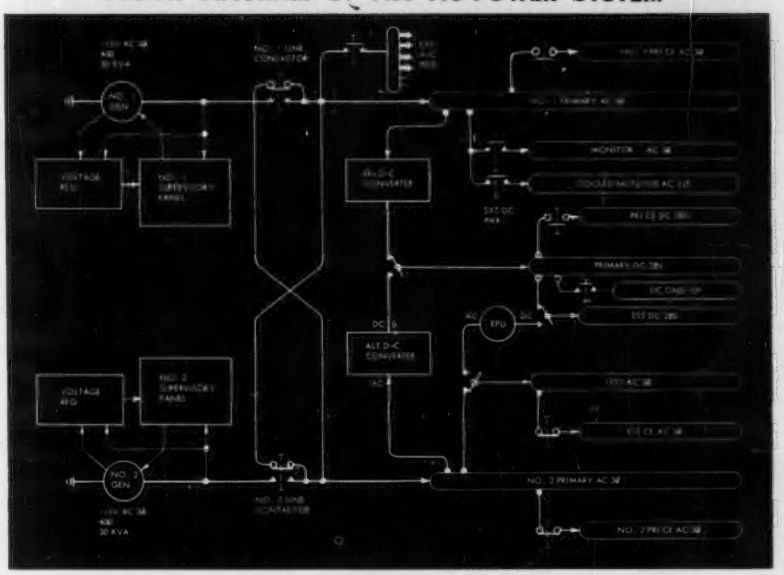
Fuel system uses two bladder cells in the fuselage, an integral tank in each wing, a "saddle" tank in the aft fuselage, and jettisonable cans in the bomb bay. External wing tanks are provided for on aircraft number 3, and subsequent. System is designed for single-point refueling, i.e., all tanks can be filled by introducing fuel at a single port on the exterior of the aircraft. In-flight refueling, and buddy-tanker capabilities are also included.

Electrical system uses no battery. The amount of special electronic, high-resolution radar, and



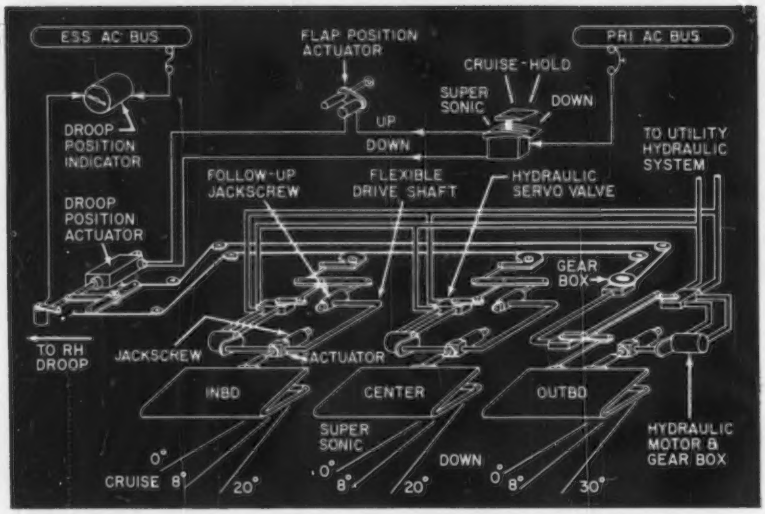
BLOCK DIAGRAM OF A3J DC-POWER SYSTEM

BLOCK DIAGRAM OF A3J AC-POWER SYSTEM



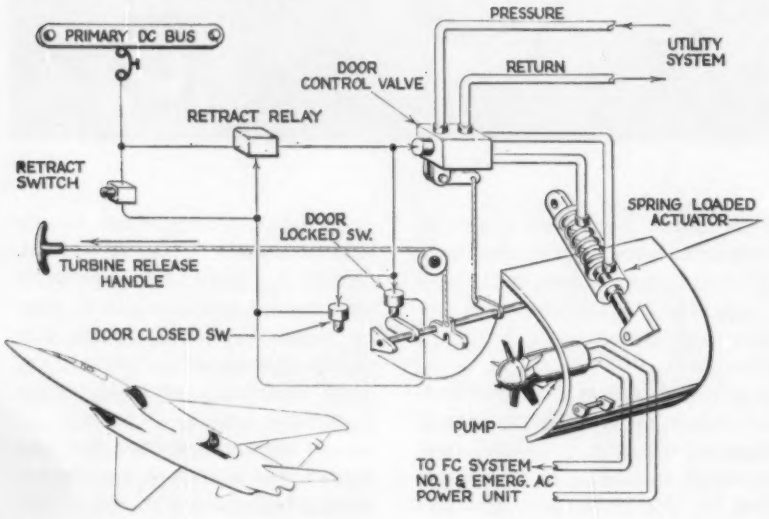
Vigilante Systems

Electrical: No Battery
Weapon Delivery: Aft Ejection



SCHEMATIC OF A3J DROOP LEADING EDGE CONTROL
Three droopable leading edge flaps are hinged at the forward-spar lower mold line. They are hydraulically operated, and electrically controlled.

RAM-AIR TURBINE provides power for emergency flight control system and emergency electrical system.



radio equipment used requires a large amount of electrical power. A battery adequate to power this equipment, even for short emergency periods, would be a tremendous weight penalty.

Electrical power is provided by 2 engine-driven 30 KVA generators that produce 115/200V, 400 cycle, 3 phase AC. The generators are brushless and are cooled by engine oil. Proper AC generation is monitored by supervisory and voltage regulation panels. Frequency is controlled by a constant speed drive unit (8000 rpm = 400 cps) mounted between the jet engine and the generator. The small quantity of 28 VDC electrical power required is supplied by transformer/rectifier units.

Emergency electrical power is provided by an emergency power unit with a 4 KVA output. Power to drive the 4 KVA generator comes from hydraulic pressure produced by a ram-air turbine which can be extended into the airstream.

Weapon-delivery system is designed around a "linear bomb bay." Two rails run longitudinally through the bay. The bomb is carried on rollers which ride these rails. A cartridge actuated ejection mechanism shoots the bomb out the aft end of the fuselage on signal. Ejection can be automatic, from the bomb/nav system or the alternate LABS equipment, or it can be manual by pilot control. Emergency jettison provisions are also included.

Ground support is facilitated by coordinated systems and airframe design. Programmed, integrated test equipment and "go, no-go" pre-flight devices are used.

Electrical System

Typical of the electrical, hydraulic and flight control systems is a degree of circuit redunancy, intersystem coordination, and weight reduction that would have been almost impossible without weapon system planning.

Design of the electrical power layout comprises a dual AC

system, a DC system, and an emergency system.

Dual AC power design consists of a No. 1, and a No. 2 system. They are normally independent of one another. Each has its own generator system, and power distribution system. The number one generator is driven by the starboard power plant; the number two generator is driven by the port. Both power distribution systems can be powered by one generator, if the other fails. Hence, both engines or both generators must fail to require "emergency" measures.

Normal operation of the two AC generator systems requires no attention by the pilot. If a failure, or low voltage is sensed on No. 1, the switch to No. 2 is automatic. Cockpit lights provided for each generator signal the one in use. A unit called the supervisory panel provides the signal for controlling the line contactor which connects or disconnects the generator from its normal distribution system.

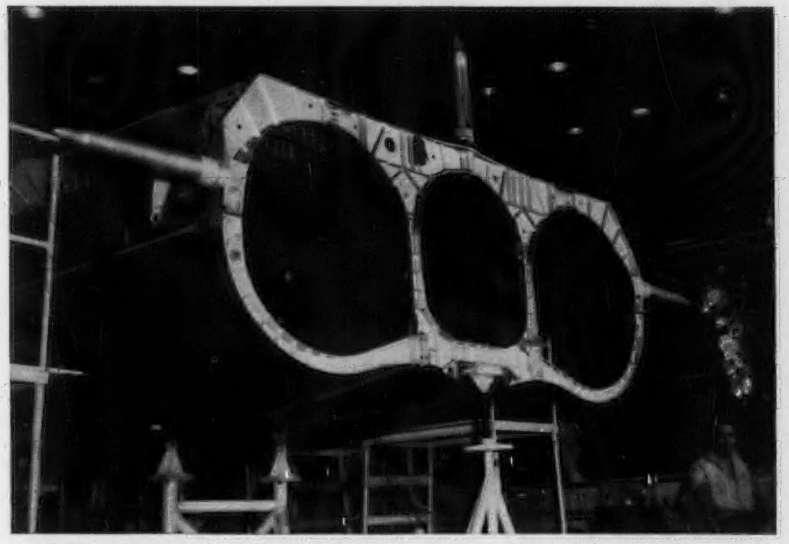
Power distribution systems (No. 1 and No. 2) each consist of a main primary AC bus, and several associated buses. The main primary AC buses are normally connected, by the line contactors, to their related generators. But, with one or both generators out, they are connected to each other through a cross-over circuit. The associated buses (the cooled equipment, the monitor and the essential) are connected by individual bus control circuits to the main AC buses. See block diagram.

The main primary buses supply loads which require no special monitoring. The cooled equipment buses power equipment which must be cooled by refrigerated air.

Cooled equipment buses are always connected to the primary buses in flight, but become disconnected if ground operation is attempted without a suitable supply of external cooling air. The essential bus supplies power for equipment essential to safe flight. If both generators fail, the essential bus can be powered by the emergency power system.

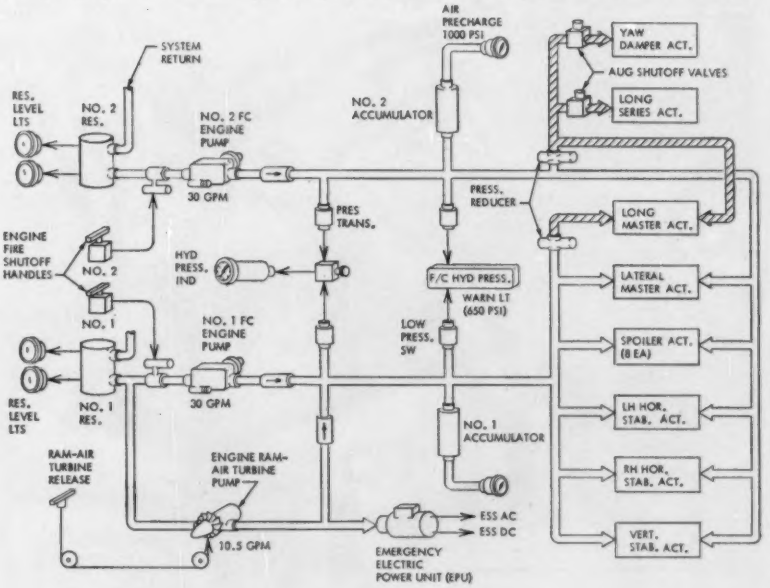
Both the monitor and cooled monitor buses are disconnected during afterburner operation when one generator is on the line. However, only the cooled monitor bus is disconnected if ground operation is attempted without cooling air.

The DC power system has a primary converter, an alternate converter, and a DC power distribution system. The two converters are identical, one is a standby. The function of the converters is to change 115/200 three phase AC power to 28 VDC power. Normally, the primary converter, powered by the No. 1 primary AC bus, supplies the DC power distribution system. If it fails, the standby, powered by



PIVOT POINTS for tail surface controls are shown in this 3-piece, weld reinforced, H-11-steel forging. Two outboard ports in forging are for engines. Center port is for ejection of bomb.

DUAL SYSTEMS connected in parallel provide hydraulic power for primary flight controls. One system is connected to starboard engine, other to port. Either system provides adequate pressure if other fails.



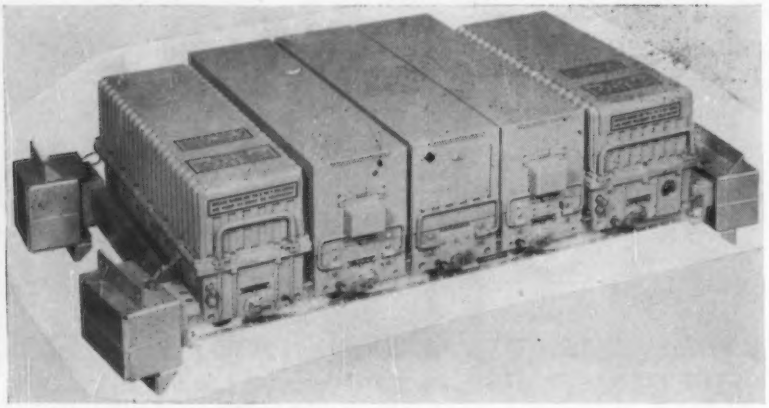
Vigilante Systems

AFCS: "Grand-daddy" of the Autopilot
Electronics: Integrated Modules

the No. 2 primary AC bus, supplies the DC system.

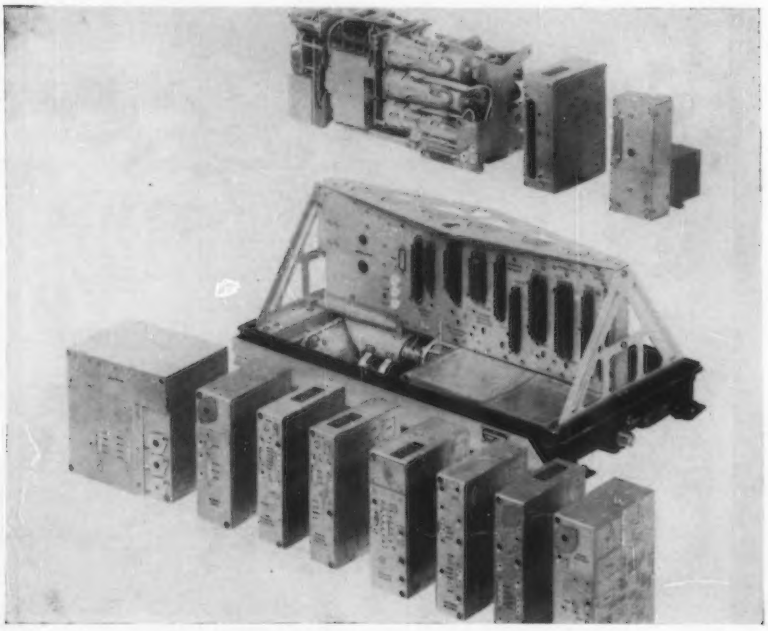
If these DC sources fail, the DC equipment essential to safe flight can be powered by the emergency power system. See accompanying diagram.

Emergency electric power comes from a ram-air turbine which can be extended into the airstream. The turbine provides 11 gpm-3000 psi hydraulic power to drive the AC-DC power unit. It feeds power to the essential AC and DC buses automatically (but only if the pilot has the No. 1 flight control system engaged).



INTEGRATED ELECTRONIC SYSTEM consists of five major "black box" modules. UHF communications, ADF and TACAN homing, instrumentation, and IFF are incorporated.

MODULAR DESIGN of each black box is apparent from this typical breakdown. Collins Radio designed the system.



Flight Control System

Flight control system in the A3J is hydraulically powered. Four pumps are used, two per engine. The flight controls are divided into two classes, primary and secondary.

The primary controls consist of those surfaces actuated by the pilot's control stick, and the speed brake. Hydraulic power for these controls is supplied by two independent, parallel systems. One system is connected to the port engine, the other to the starboard. Hydraulic pumps are variable displacement and supply 31 gpm at 3000 psi.

The secondary controls consist of wing flaps, and droopable leading edges. Hydraulic power for these controls comes from the utility hydraulic system. This hydraulic system is of 3000 psi, closed center, unbalanced design. Two Vickers rotary-piston, variable-displacement pumps are used. One is run by the port engine, the other by the starboard. If one pump or engine should fail, the other can supply adequate fluid (15 gpm at 100 percent engine rpm).

Emergency flight control hydraulic power is provided by the ram-air turbine previously discussed. The turbine drives an 11-gpm pump, which is connected to the lines normally used by the port engine pump in the primary flight control system.

Ground servicing of the entire flight control system is done at a single panel just aft of the left-main landing gear. Fittings for pressure filling from an hydraulic power cart or from a hand pump are provided. The controls are ground checked by connecting hydraulic power carts to quick disconnects on the engine driven hydraulic pumps in each engine nacelle.

Hydraulic servo actuators (master servo actuators), normally controlled electrically, position the horizontal stabilizer actuators and the wing-spoiler actuators. Parallel mechanical systems are provided as a backup. The directional system has a conventional mechanical

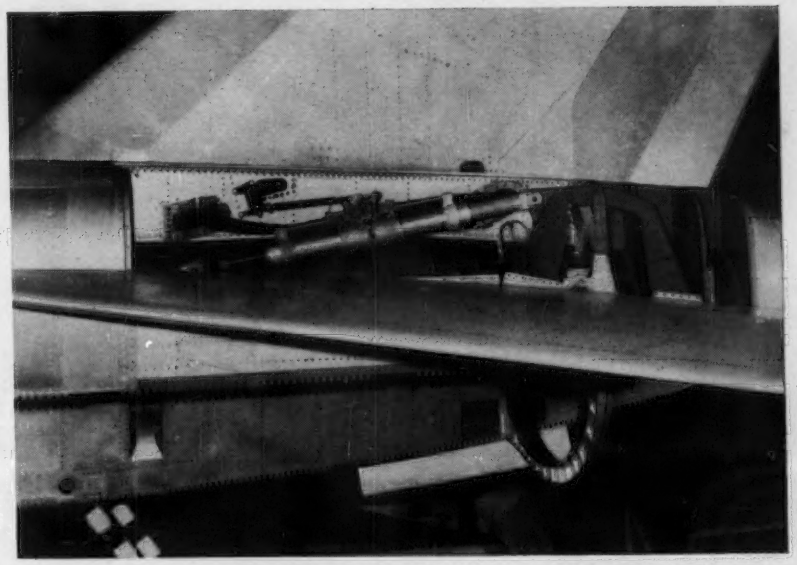
system from the pedals to the vertical stabilizer actuator.

Both master servos control the surface actuators as a function of pilot's control stick movement. Series servos in the yaw damping and longitudinal augmentation systems control the surface actuators as a function of electronic flight data signals. Control is independent of the pilot, and the cockpit controls do not move. The series servos are balanced actuators powered by the right-hand hydraulic system.

The two master servos, the horizontal stabilizer actuators, and the vertical stabilizer actuator are tandem type units normally powered by both hydraulic systems. They are capable of operating from a single system if required. The spoiler actuators function in the same manner as the others but are dual side-by-side units.

Series servo travel is limited to prevent over-control should a malfunction occur in the system.

Electric actuators provide lateral and directional trim. Each actuator has a normal and alternate source of electric power. Positioning a common trim select switch determines whether the normal or alternate control switch is effective.



HORIZONTAL TAIL SLAB is actuated by NAA produced actuator. Right slab has identical actuator hydraulically synchronized. Redundancy is built-in to complete duality of hydraulic systems.

Automatic Flight Control System

Vigilante's automatic flight control system (AFCS) is something NAA points to with pride. Hardware and design were finished essentially with "in-house" talent. The system uses many components already proven in service. But, where considerable weight could be saved, new hardware was designed. AFCS is tied into the normal flight control system, and the nav/bomb system.

Auto flight functions are:

- Heading, pitch, and altitude control.
- Angle of bank hold.
- LABS rollout and LABS pull up.
- Autonavigation.
- Mach hold.

A master flight reference system controls longitudinal and azimuth reference signals in AFCS. Altitude is controlled by an altitude error sensing unit in the Air Data System. Steering signals for autonavigation are generated by the radar-equipped navigation system.

Capabilities—Course And Bank

The AFCS amplifier receives 115 VAC power at all times when the aircraft is running. The pilot merely pushes the "engage" button when he wants to go on auto-flight-control.

Heading hold is accurate within 5 deg if wings are kept level. If the control stick is moved, then recentered, aircraft will maintain its new heading, provided the change is within ±5 deg of the original.

Angle of bank hold automatically engages when the ±5 deg bank limits are exceeded and the pilot's control stick is recentered. Bank-hold is operative between 5 and 60 deg of bank. Above 60 deg system disengages.

Integrated Electronics

An integrated electronic system provides the functions of UHF communications, TACAN and ADF navigation, instrumentation and IFF. Air Force calls this system Mission and Traffic Control (M&TC), Navy calls it Communication - Navigation - Identification (CNI). Collins Radio Co. manufactures the A3J system. It is very similar to that used in the F4H, except that mechnical configuration is changed to suit installation on the aircraft.

Modular design is used throughout this electronic system. Five major "black boxes" fit a shock-mounted shelf behind the nose wheel. Refrigerated air is circulated to the UHF, and TACAN units. Many of the nodules are "borrowed" from already proven equipment. Modular design has given Collins a great degree of flexibility in applying proven designs to weapon systems in development.

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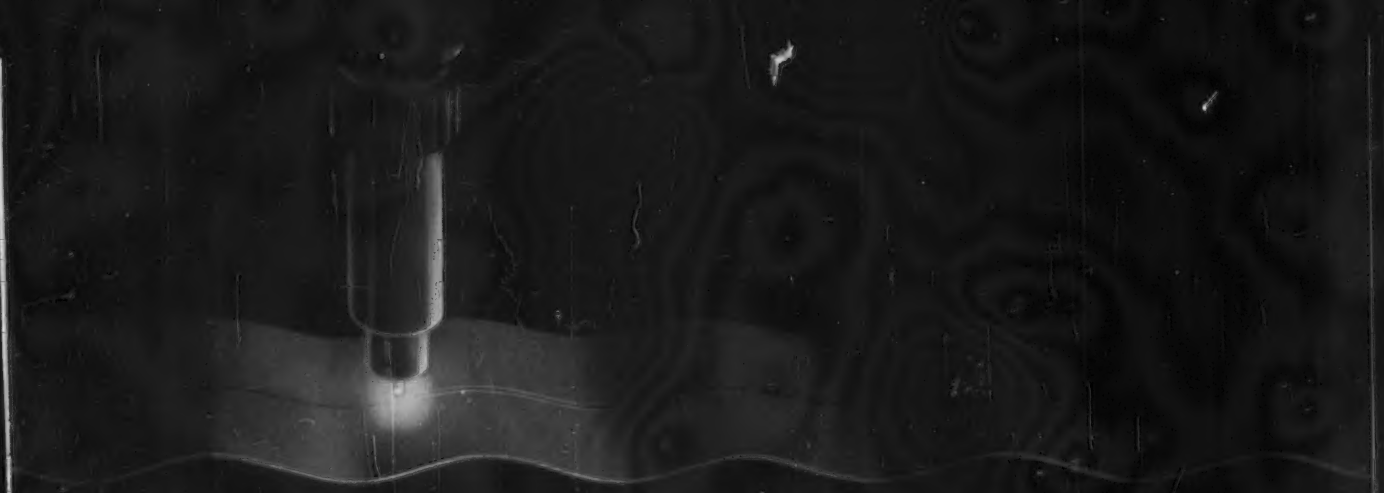

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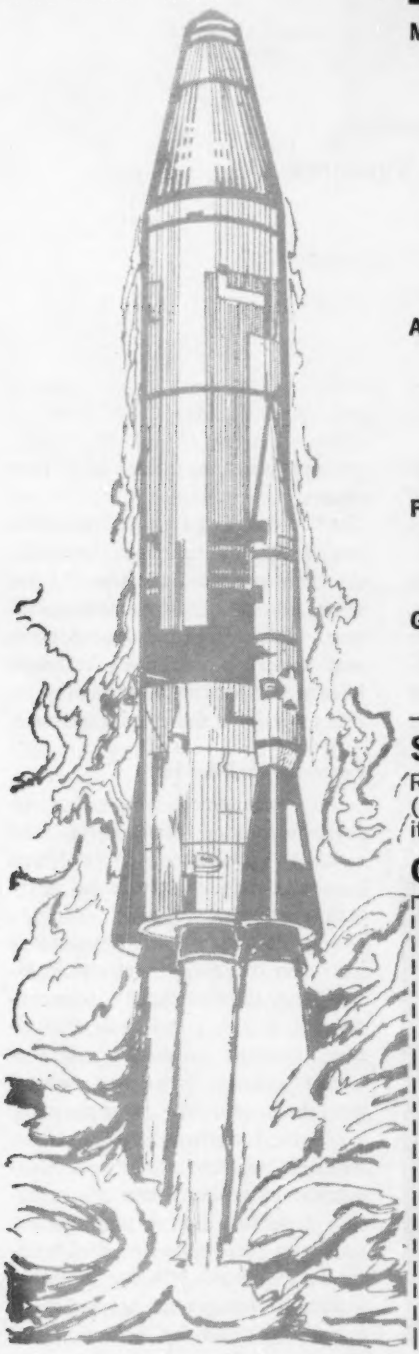

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What Radiation Does to Electronic Components

Effects Are Damaging, Can Be Temporary or Permanent;

Tests Must Be Conducted On Individual Units and Overall Systems

by S. Peter Kaprielyan

Radiation effects on electronic materials and components may be classed as transient, permanent and secondary.

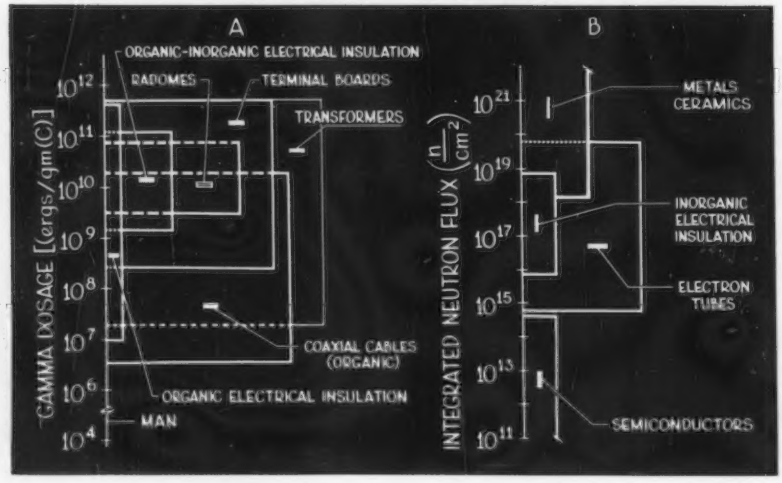
Transient Effects

These occur during irradiation but disappear afterward. Transient effects in the operational characteristics of electronic components have been investigated by Convair-Fort Worth and by International Business Machines Corp., Owego, N. Y.

Significant transient effects have been observed in transistors, photo diodes, insulation resistance and/or air ionization, and capacitance. An increase in conductivity of some dielectrics, as a function of gamma dose rate, has also been observed.

Recovery-time of dielectrics varies with the material. Generally, return to pre-irradiation level takes about 10 to 12 hr at room temperature. However, even in components and materials exhibiting transient effects, permanent damage may result after high radiation exposures.

RELATIVE RADIATION-RESISTANCE OF VARIOUS ELECTRONIC MATERIALS AND COMPONENTS

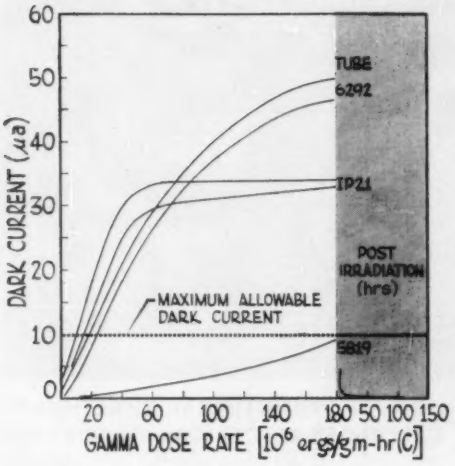


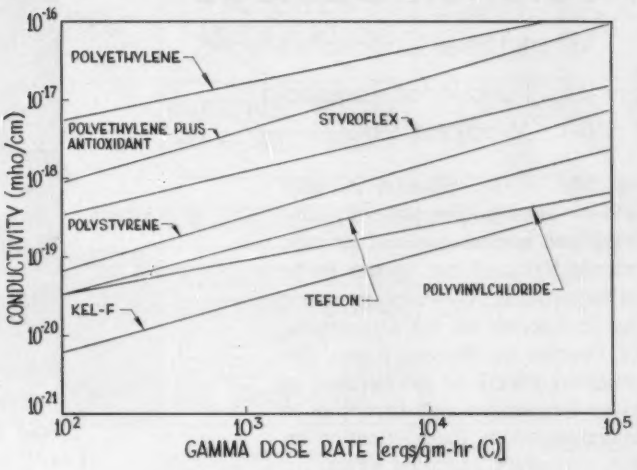
Permanent Effects

Permanent effects are irreversible; they depend on total radiation received (dose effect), and may be dependent on radiation intensity (dose-rate effect).

Permanent radiation damage has been observed in electrical insulations, electron tubes, semiconductors, potting compounds, capacitors, resistors, radomes, printed-circuit boards, frequency control crystals, transducers, transformers, electrical connectors, flotation fluids, lubrication greases, etc. Inorganic materials are more radiation resistant than organic materials; an exception is the semiconductor class. Nuclear radiation produces changes in properties of organic materials by ionization and

HOW GAMMA RADIATION AFFECTS PHOTOMULTIPLIERS AND DIELECTRICS





excitation processes which cause chain scission, cross linking, free radical formation, and polymerization of molecules. Gamma rays are the ionizing radiation of primary concern in organic damage work. Inorganic material damage, such as lattice structure displacements in ionic - and - metallic - bonded materials, is primarily caused by neutrons.

In a reactor environment, the radiation field is mixed, containing neutrons and gamma rays of various energies. Hence, damage must be analyzed with respect to the radiation component which is primarily responsible for the damage. Surface area exposed, and radiation attenuation afforded by the material influence the extent of damage. For example, very thin materials are less subject to secondary particle capture and multiple scattering. This means less energy absorbed by the material, hence, less radiation damage. Generally, maximum energy absorption, per unit of weight, occurs in thicknesses varying from a few thousandths of an inch up to about one inch. Self-shielding reduces the incident radiation, thus protecting the subsurface material from damage. However, for most electronic components, the self-shielding effect is small.

Secondary Effects

Included among these are such radiation-induced phenomena as liberation of gas from organic materials and fluids, nuclear heating, air ionization, and electromagnetic wave attenuation.

Gas evolution usually results from bond cleavage. In designing hermetically sealed relays, knowledge of the amount and types of gases evolved is vital to avert case rupture or the formation of explosive mixtures; installation of a pressure-release valve may alleviate this problem.

Nuclear heating may result from the energy deposited in materials and components by the scattering and absorption of incident neutron and gamma rays. This is particularly true in a nuclear radiation field of high intensity, hence, cooling provisions may need consideration.

Ionizing effects of radiation in organic insulators produce complex chemical reactions (crosslinkage or cleavage of molecular chains) which drastically alter the nature of the material. These changes reduce the breakdown voltage and increase

FAILURE DISTRIBUTION OF LOW-FREQUENCY TRANSISTORS

leakage currents during irradiation; after irradiation, insulation often shows an increase in electrical resistivity and dieleltric strength.

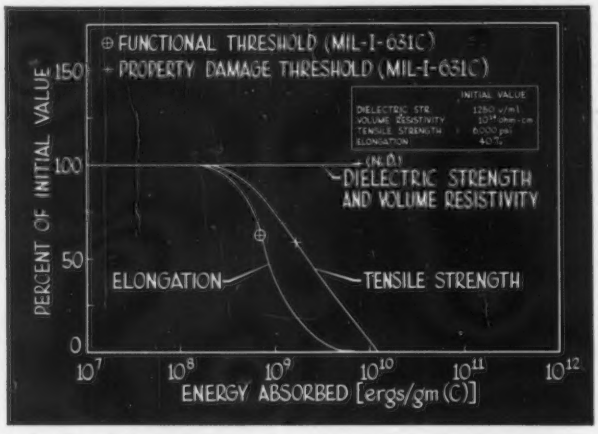
Studies were made at Battelle Memorial Institute for Lockheed Aircraft to determine the performance of electrically-insulated wire in a nuclear environment. Results showed severe damage to polymeric insulation. All insulations showed a loss in initial resistance of about 99 per cent. Mechanical properties were maintained only in wires using polyethylene insulation.

Electromagnetic wave attentuation results from free electrons produced by nuclear radiation through air ionization. This attenuation is a function of the free electron density which in turn is a

Radiation Damage

What These Concepts Mean:

(1) "Functional Threshold"
(2) "Weakest Link"



DETERMINATION OF "FUNCTIONAL THRESHOLD" FOR ETHYL CELLULOSE ELECTRICAL INSULATION

function of the radiation intensity and air density. For presently contemplated nuclear-powered aircraft, attenuation does not appear to be of importance. However, in recent public releases by the Department of Defense on Project Argus, the observed effects of interference in radar frequencies and disruption of communications focus attention on this secondary radiation effect.

Radiation Effects Analysis

Preliminary design analysis of electronic systems, for nuclear-powered aircraft, includes the following steps:

- Determination of system composition and operation.
- Materials and components evaluation.
- Initial system analysis.
- Recommendation of materials or components replacements.
- Final system analysis.

Knowledge of complete system composition is vital, since the validity of radiation effects analysis is no better than the data input. System composition should include material type, manufacture, and construction details. Operational characteristics are needed to determine effects of component interaction and environment, and to determine component requirements.

Evaluation of system materials and components using "func-

ELECTRONIC SYSTEM ANALYSIS TO DETERMINE "WEAKEST LINK" IS BASED ON INPUTS A, B, C, D

INPUT "A"

FUNCTIONAL SYSTEM DESCRIPTION

INPUT "B"

WADC GRADE E RADIATION REQUIREMENTS

nf/cm²-sec: 1.0(9)
ergs/gm-sec(C): 5.0(3)
LIFE: 1000 HOURS

BLACK BOX

INPUT "D"

PART BREAKDOWN

MATERIAL OR COMPONENT	TYPE	FUNCTIONAL THRESHOLD	BASIS
ELECTRON TUBES	VACUUM	5.9(14)* n/cm²	1% FAILURES
	GAS	9.0(15) n/cm²	1% FAILURES
	PHOTO.	6.1(2)[ergs/gm-sec(C)]	#5819 SPEC. FAILURE
TRANSISTOR	LOW FREQUENCY	6.5(11)n/cm²	TRUNCATED LOGISTICS DISTRIBUTION
CAPACITOR	MICA	4.0(17)n/cm²	PHYSICAL DAMAGE
ELECTRICAL INSULATION	TEFLON	2.0(8)[ergs/gm(C)]	PHYSICAL & ELECTRICAL PROPERTY DAMAGE
RESISTOR	DEPOSITED FILM (BORON)	7.0(7)[ergs/gm(C)]	INCREASED RESISTANCE

INPUT "C"

WADC GRADE E NON-NUCLEAR REQUIREMENTS

TEMPERATURE	ACCELERATION
PRESSURE	SAND AND DUST
SHELF LIFE	SUNSHINE
MOISTURE	RAIN
ELECTROLYSIS	SALT ATMOSPHERE
VIBRATION	FLAMMABILITY
SHOCK	FUNGUS RESISTANCE
ACOUSTICS	

* NUMBERS IN PARENTHESIS INDICATE POWERS OF TEN

MATERIAL OR COMPONENT	TYPE	PREDICTED NUCLEAR LIFE (HOURS)	POSSIBLE MODIFICATION	REPLACEMENT PREDICTED LIFE (HOURS)
ELECTRON TUBES	VACUUM	160	ADDITIONAL TESTING OR DEVELOPMENT	> 1000
	GAS	2500	———	———
	PHOTO	NO TRANSIENT RADIATION EFFECTS PROBLEM		———
TRANSISTORS	LOW FREQUENCY	[redacted]	JUDICIOUS SELECTION, ADDITIONAL TESTING, DEVELOPMENT OR REDESIGN TO ELIMINATE TRANSISTORS	> 1000
CAPACITORS	MICA	$1.1(10^5)$	———	———
ELECT. INSULATION	TEFLON	11	FORMVAL ELECT. INSULATION	>1000
RESISTORS	DEPOSITED FILM (BORON)	770	DEPOSITED FILM (NO BORON)	>1000

[redacted] WEAKEST LINK

SYSTEM ANALYSIS SUMMARY CHART SERVES TO LOCATE "WEAKEST LINK" COMPONENT

tional thresholds" comes next. A functional threshold is defined as the minimum amount of nuclear radiation required to change the properties of a material or functioning component to values outside the specification limits.

Functional threshold determination for ethyl cellulose electrical insulation is illustrated. In this case, however, data were not available on additional properties including softening temperature (penetration), lengthwise shrinkage, dissipation factor, and dielectric constant. Both dielectric strength and volume resistivity thresholds are based on "no damage" (N. D.) thresholds. A "no damage" threshold exists when property data have not exceeded specification limits at the conclusion of irradiation.

Where radiation data permit, a failure distribution can be obtained by using statistical techniques.

System analysis to determine radiation effects follows the material and component evaluation. Two methods of system analysis are currently practiced: the "weakest link" concept and the "computer simulator" technique.

Weakest link concept is based on the premise that a system is no better than the component most sensitive to irradiation. In the example of a "Black Box," illustrated here, the functional description of the system, the radiation environment, the non-nuclear environment, and the materials-and-components part breakdown are all inputs into the system analysis.

Computer simulator technique involves varying the characteristics of system components according to changes observed during irradiation. Response of the system is then studied as a function of radiation exposure. In this manner more realistic tolerance levels for use in functional threshold determinations are established. Also, component interactions, both additive and compensating, in complex electronic systems are studied, and possible circuit redesign features which allow for property changes during irradiation are examined.

Based on the following sources: Convair-Fort Worth report FZM-1826, "Radiation Effects—A Major Consideration in the Design of Electronic Systems for Use in Nuclear-Powered Aircraft," by J. H. Levine and W. F. Ekern; Battelle report "Radiation Effects on Insulation, Wire, and Cable," by C. J. Lyons and R. I. Leininger.

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Satellite Instrumentation

Design and Mission of Two IGY-satellites Show Achievements in Microminiaturization; Last Vanguard Carries Advanced Magnetometer

The last of the Vanguards was fired from Cape Canaveral on September 18, under NASA's guiding hand. It placed a 50-lb satellite in orbit and brought the "hot-potato" program to a graceful end.

Special Magnetometer

Aboard the satellite (1959 Eta) are experiments to measure the earth's magnetic field, X-radiation from the sun, and several aspects of the space environment through which the satellite travels. For magnetic field measurements, a new-type magnetometer capable of much greater accuracy than those in previous experiments is being used.

Designed and built by NASA and Varian Associates, the magnetometer consists of a copper coil filled with liquid (hexane) located in the tip of the magnetometer tube. Wires connect the coil to the electronic equipment and batteries in the satellite sphere. On command from a ground station, the coil is energized by 6½ amp of electrical current. This, in turn, orients the protons (H+) in the liquid and causes them to spin within the coil in a prescribed manner.

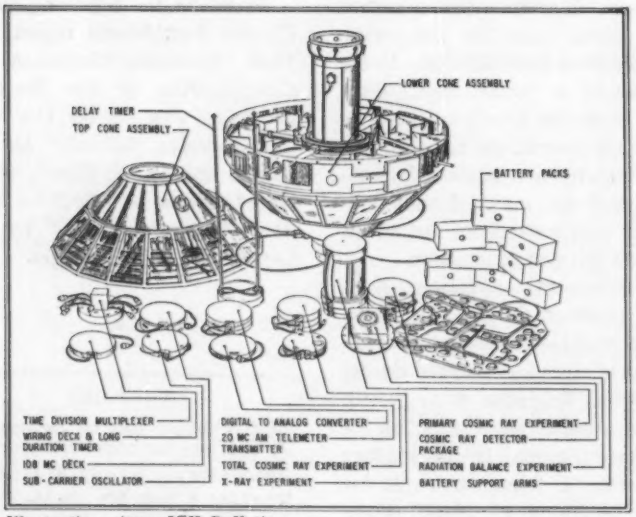
After the current stops, about 2 sec later, the protons spin for another 2 to 2½ sec in wobbling orbits dictated by the earth's magnetic field. The frequency of the proton motion imparts voltage to the coil. This voltage is then amplified and transmitted instantaneously to the ground receiver, where it is taped. Simultaneously, a reading is made at the ground magnetometer, with which each of the interrogating stations is equipped.

Analysis and comparison of the satellite and ground readings will supply much information about the shape, intensity, and variations of the earth's magnetic field. Besides providing additional calibrations for determination of the main geomagnetic field, the simultaneous readings at ground stations will help locate and define ionospheric currents, since measurements both above and below the ionosphere are needed to delineate such currents.

The satellite is interrogated about 50 times a day for magnetic data, or about twice on each pass over a tracking station.

Launch vehicle was standard, with two exceptions. Third stage was converted to a solid 3000-lb thrust with a 10-sec longer burning time. This single fact doubled orbit payload weight. Other change was that the 3rd stage did not separate from the satellite.

EXPLORER VII (also called 1959 Iota) weighs 91.5 lb. Shaped like a double cone joined by a center ring, it is 30 in. long and 30 in. wide. Shell is glass-plastic honeycomb structure.



Illustrations from IGY Bulletin

Explorer VII

Carrying the largest and most varied payload in US-IGY satellite efforts, the Juno II—launched Explorer VII was placed in orbit on October 13.

Experiments aboard include measurements of the Earth's radiation balance, heavy primary cosmic rays, solar ultraviolet radiation, micrometeorites, cosmic rays and other particles, lifetime of an unprotected solar cell, and surface and inner or temperatures. A 20 mc primary telemetry frequency and 40 mc and 60 mc harmonics permit ground-based studies of the ionosphere.

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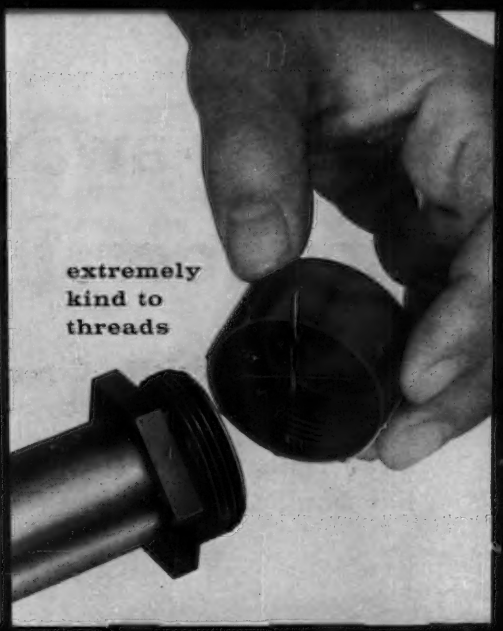

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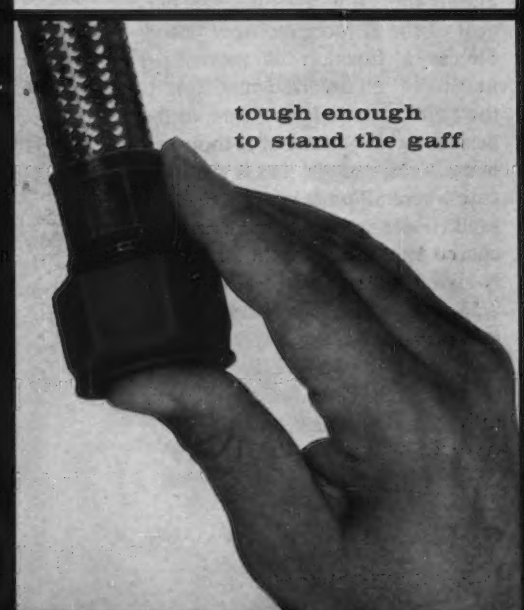

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Throw-away Electronics— Consideration for Designers

Tube and Transistor Circuits Most Probable Areas to Begin;

Save Time, Space, Money with Throw-away Modules, But Don't Overlook Time-to-Failure Requirements

By **R. E. Kuehn,** Mgr. Reliability Engineering, IBM—Owego

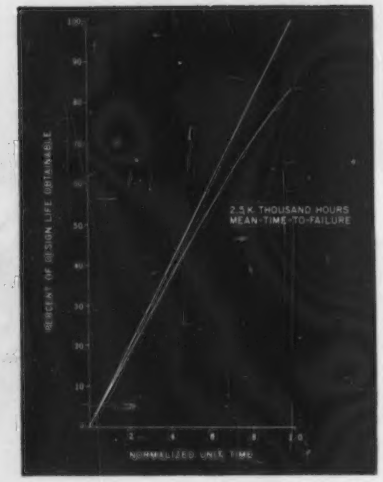
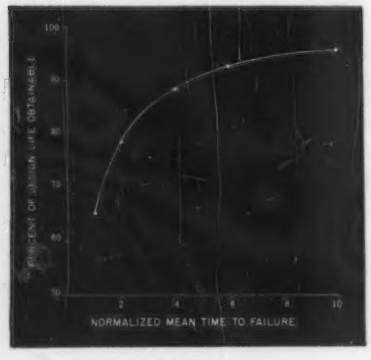


Fig. 1. Percent of Design Life Obtainable vs. Normalized Unit Time for a Unit With Mean-Time-To-Failure of 2.5 K Thousand Hr.

Fig. 2. Percent of Design Life Obtainable As a Function of Normalized Mean-Time-To-Failure.



The throw-away concept in electronics design means that from the outset, the equipment will be considered non-repairable and expendable. To effect the throw-away concept, the customer and the manufacturer must consider the following:

- The relationship between the design operating life of a system, and the required mean-time-to-failure of the throw-away units.
- The complexity and trouble shooting requirements of the throw-away units.
- The volume and reliability versus repairability trade-offs.
- The economic justification of the throw-away concept.

Mean-Time-To-Failure

Mean-time-to-failure of a unit is its most probable operating life. Desired operating life of an overall system is directly related to the life of its units. Mean-time-to-failure of throw-away units must, therefore, be included in the design specifications of the system. A commonly used system specification states: "The probable operating life of a system shall be in excess of K thousand hours when operated under . . . required service conditions. . . ."

Under these provisions the intent would be to obtain more than K thousand hours on every unit before failure. On a normal distribution basis this would require an infinite mean - time - to - failure, which naturally is not attainable. If the throw-away concept is to be effected, a compromise must be reached.

Basis for compromise is suggested in Fig. 1 and Fig. 2. Mean-time-to-failure is considered as a function of system design-operating-life. Fig. 1 shows the percent of the K thousand hour design life as a function of normalized unit time. Normalized unit time is the ratio of unit elapsed time to the design operating time of K thousand hours. The straight line is the ideal case where all units operate K thousand hours without failure. The curved line shows that a statistically significant sample of a unit with 2.5K thousand hours mean-time-to-failure would actually provide the customer with 83 per cent of the possible unit hours at the end of the K thousand hour test.

Fig. 2 shows the per cent of design life obtainable in a K thou-

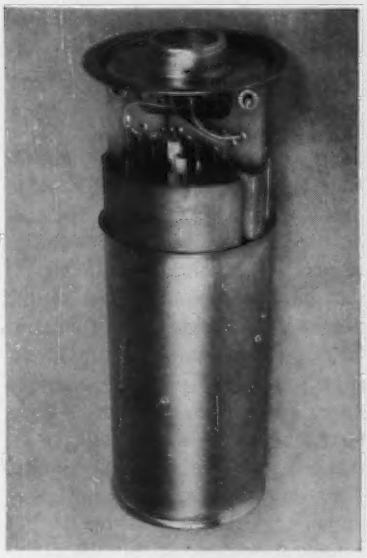


Fig. 3. System amplifier for heavy aircraft had reliability upped 40 percent by throw-away design.

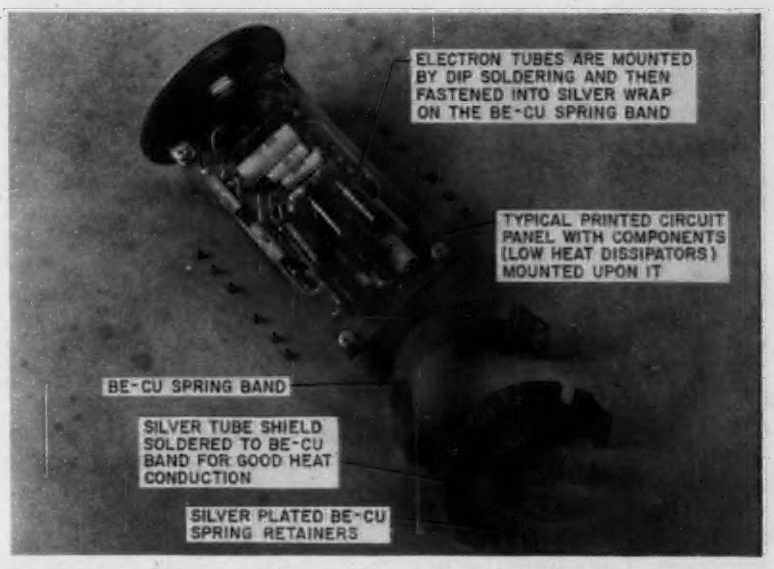

ELECTRON TUBES ARE MOUNTED BY DIP SOLDERING AND THEN FASTENED INTO SILVER WRAP ON THE BE-CU SPRING BAND
TYPICAL PRINTED CIRCUIT PANEL WITH COMPONENTS (LOW HEAT DISSIPATORS) MOUNTED UPON IT
BE-CU SPRING BAND
SILVER TUBE SHIELD SOLDERED TO BE-CU BAND FOR GOOD HEAT CONDUCTION
SILVER PLATED BE-CU SPRING RETAINERS

Fig. 4. Internal details of the amplifier show major units on printed board. Back-to-back printed circuits are used. Cooling was main design goal. 50 percent space saving results with throw-away design.

sand hour test, as a function of normalized mean-time-to-failure. Normalized mean-time-to-failure is the ratio of unit mean-time-to-failure to the K thousand hour design operating life.

The point of unit slope occurs for a mean-time-to-failure of 2K thousand hours. The gain in per cent beyond 2K thousand decreases at a rather rapid rate as the mean-time-to-failure increases. On the basis of these figures, the equipment manufacturer should design mean-time-to-failure of the throw-away units at 2.5 times the intended unit operating life.

System reliability demands will be dictated by end use.

Tube and Transistor Circuits

Economics make electron tube and transistor circuitry the most probable areas for the throw-away concept at present. As an example, consider an electron tube system giving the necessary amplification, sweep generation and wave shaping circuitry required by a visual display. With an operating life requirement of 2,000 hr, the individual throw-away units must have a minimum mean-time-to-failure of 5000 hr. With an average of 8 component parts such as resistors, condensers, and pulse transformers for each miniature or subminiature vacuum tube, the maximum tube complement of the throw-away unit would be about eight. Component part derating, sufficient cooling and large circuit margins on component part characteristics are required to obtain 5000 hr mean-time-to-failure for an eight-tube unit.

A large-scale, transistorized digital-computer with life requirement of 40,000 hr should have throw-away units with a minimum mean-time-to-failure of 100,000 hr. With an average of four component parts such as resistors, condensers and diodes for each transistor, the throw-away unit would have a maximum of about seven transistors. Effective cooling, and circuitry insensitive to transistor drift and distribution are necessary to realize 100,000 hr mean-time-to-failure for a unit with seven transistors.

Trouble Shooting

Trouble shooting can be come a problem. A system with over 50 throw-away units contains a large number of interconnecting cables and connectors. Trouble shooting by unit replacement is less effective as the number of individual units increases. The liberal use of accessible test points and built-in test problems proves valuable as trouble shooting aids. To aid maintenance, careful considerations should be given to unit test equipment designed for "Go, No-Go" operation, test equipment built as an integral part of the system, malfunction indicators, and diagnostic programming. Training maintenance personnel to trouble shoot by means of data flow appears to be a

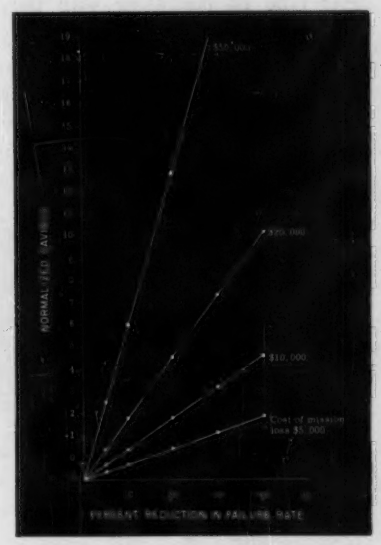


Fig. 5. Normalized Savings As a Function of Percent Reduction in Failure Rate.

Throw-away Electronics

No Turning Back

necessity for a system having a large number of functional units.

Save Space

Even in large aircraft the volume of electronic equipment must be kept to a minimum. Ruling out repairability permits the design of units with a very high packing factor and a reduced volume. The design illustrated in Fig. 3 and Fig. 4 utilizes back to back printed circuit boards with flush mounted components. This construction permits assembly starting from the inside and progressing in stages to the completed assembly. Using the same type of packaging with the repairability requirement that every component part be accessible without removing any other component, the same unit would require fifty per cent more volume. For a given type of packaging, the decision to throw-away instead of repair will result in reduced volume.

Up Reliability 40 per cent

Throw-away design, utilizing a dry inert-gas in a hermetically sealed container or encapsulation, can eliminate humidity and corrosion as problems. With no repair requirement, a small, rigid assembly can be designed with a high natural resonant frequency and an excellent resistance to vibration damage.

Design possibilities for cooling electron tubes and high wattage dissipating component parts are shown in Fig. 3 and Fig. 4. The crimped tube shield used in this design was developed with no need to consider quick removal and replacement of the electron tube. Consequently, efficient cooling was the only design requirement. The temperature drop across this shield for watt of dissipation is half that of a tube shield where replacement is a requirement. Using the relationship that electron tube failure rates vary as the 5th power of the temperature ratio, the tube shield should reduce the failure rate by about 50 per cent for maximum design temperatures and maximum electron tube dissipation.

Considering all the factors mentioned above, it is estimated that eliminating repairability as a design requirement resulted in a 40 per cent reduction of the failure rate. This improvement in reliability of a throw-away design over a repairable design, using the same basic configuration, has important economic considerations as well as operational importance.

Save Money

Economic considerations become complex in justifying throw-away. At the present, most of the data on which to base sound economic decisions is not available. A number of controversial areas which require attention are:

- Cost of throw-away unit.
- High-value-item provisioning.
- Maintenance level at which throw-away is authorized.
- Return of early failures to manufacturer to guide product improvement.
- Supply support throughout operational life of system.
- Requirements for service manuals.
- Comparison of throw-away cost to repair cost over system operating life.

Cost of Unreliability

Throw-away is justified economically by considering the cost of unreliability. By a previous estimate, the trade-off of reliability versus repairability results in a 40 per cent reduction of the failure rate. The system considered has about 90 units designed for throw-away and is intended for heavy manned aircraft. Fig. 5 shows the normalized savings as a function of per cent reduction in failure rate for four cases. A mission loss due to unit failure is assumed to cost 5, 10, 20, and 50 thousand dollars respectively. Normalized savings is the ratio of dollars saved to the dollars cost of throw-away units at 2000 hr operating life. It is assumed that one out of every four hours of operating life is a flight hour, and that failures occurring on the ground have no cost penalty. For repairable and throw-away units it is further assumed that trouble shooting costs are the same, and, to avoid controversy, that the repair of repairable units is free.

With all of these concessions, the 40 per cent increase in reliability gives a saving of 1.8 times the cost of throw-away for the $5,000 mission loss, 4.59 for the $10,000 mission loss, 10.2 for the $20,000 mission loss, and 26.9 for the $50,000 mission loss. The cross-over points for the 5, 10, 20, and 50 thousand dollar mission loss are at 14.5, 7.2, 3.7 and 1.5 per cent reduction in failure rate. If the ratio of flight time to operating time is increased, there will be a proportional increase in the savings realized.

Change of Mind Costly

Once direction has been given to design for throw-away, the decision to repair hardware that has malfunctioned can be very costly. One of the most important factors to consider is the failure rate of the repaired units compared to the failure rate of new units. Early data indicate a serious deterioration of the reliability of repaired units that were originally designed for throw-away.

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There is much talk in the industry about state-of-the-art capability in stainless honeycomb sandwich fabrication. Actual *production experience* in this new field of exotic materials and structures still is limited to a relatively few companies. *And Aeronca is one of them.*

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The supersonic speed brake assembly illustrated below is an example of our capability. This design, one of the most intricate brazed stainless structures produced to date, is 75" long, 46½" wide and 3½" deep. Its complex cross-section required extremely precise forming and machining as well as special tooling and process control.

Whatever your honeycomb requirements, you can save time, expense and headaches by utilizing our extensive experience and facilities. Our customers will verify that *Aeronca produces results . . . not claims!*

This 120" curved section is typical missile structure.

Stainless honeycomb components for B-58 "Hustler"

Top view of new speed brake assembly.

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SNAP III—Electrical Power For Space Probes

Reliable, Compact Power Source Needed For Auxiliary Systems; SNAP III Looks Promising, Uses Thermionic Conversion

One of the greatest needs for space exploration is a reliable and compact source of electrical power. Solar cells and isotopic power seem to offer the best prospects to-date. Isotopic power is of particular interest because it is independent of solar radiation which may not always be available. Space probes will operate within the shadow of planets, or under the atmosphere blanket on the surface of planets. The exploration of Venus would present such a problem.

Power Theory

The theory of isotopic power has long been recognized. When particles emitted during the spontaneous decay of a radioisotope are absorbed by surrounding material, heat is produced. Since the half-life (time required for disintegration of one-half the atoms) of a radioisotope is fixed by nature, the amount and duration of this heat emanation can be predicted. Some radioisotopes have half-lines of many years, heat sources can be produced which can outlast any conceivable system of chemical batteries. Power thus produced can be used as heat, or it may be converted into electricity.

Heat can be converted into electricity in various ways. Obvious way is by using heat to produce steam, which drives a conventional generator. But, direct conversion (thermoelectric or thermionic) involves less weight and improved reliability, since no moving parts are used.

Direct Conversion

In a thermionic conversion device, electrons are "vaporized" off a hot cathode and collected on a relatively cooler anode; an electron flow results in a wire connecting the two plates. In a thermoelectric system, a heat source is connected to another point having a considerably lower temperature; connection is made by two materials, each having dissimilar electrical characteristics.

In a common thermocouple, metals are used for the connection. It has been found, however, that if instead of metals, semiconductors (alternately "doped" to produce a deficiency or an excess of electrons) are used, far greater efficiency is obtained. In either case, an electromotive force is generated between the two materials.

SNAP III (Subsystem Nuclear Auxiliary Power) uses the semiconductor materials for direct conversion.

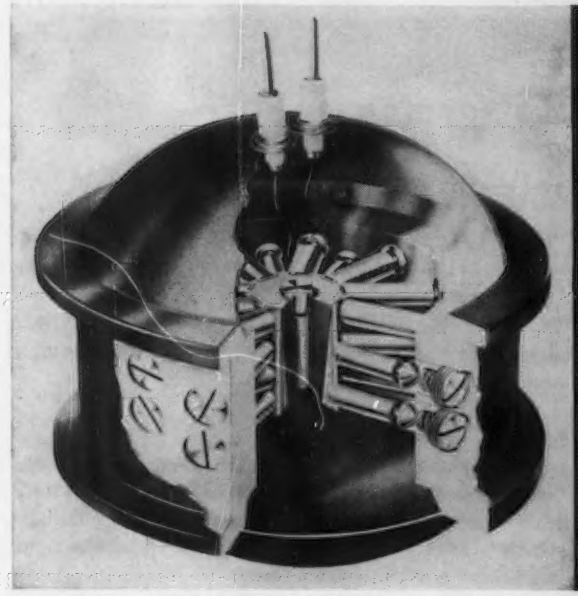
Specific Power of Various Isotopic Power Sources

Isotope	Fuel Form	Practical Density (gr/cm^3)	Specific Power (w/cm^3)
Polonium-210	Po	9.4 (solid)	90.0
Curium-242	Cm.8 Pt	15.6	256.0
Curium-244	Cm	7.0	20.0
Plutonium-238	PuC	12.5	6.9
Plutonium-238	Pu	16.0	9.3

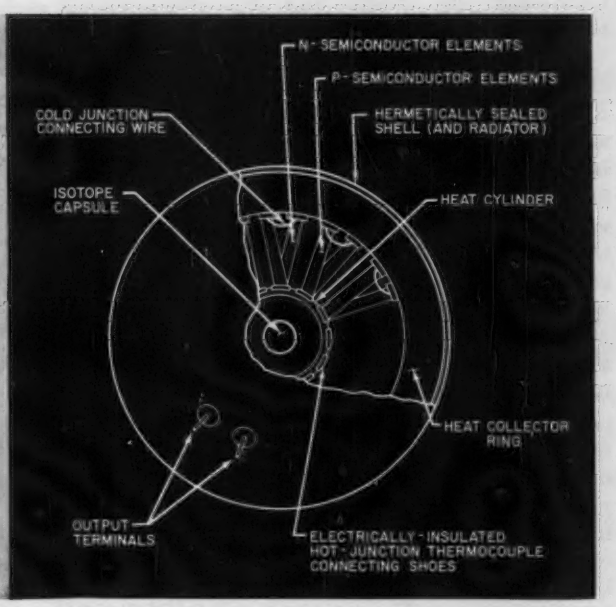
Radiation Associated with 100 Thermal Watts of Various Isotopic Power Sources

Isotope	Fuel Form	Gamma Radiation (1 yd, rem/hr)	Neutron Radiation (1 yd, rem/hr)	Total Radiation (1 yd, rem/hr)
Po-210	Po	0.020	0.0065	0.0265
Cm-242	Cm-8Pt	0.0043	0.0325	0.0368
Cm-244	Cm	0.0083	0.0045	0.0128
Pu-238	PuC	0.00001	0.00078	0.00079
Pu-238	Pu	0.00001	0.00053	0.00054

The Atomic Energy Commission has decided that humans working in a radiation field for 40 hr/wk can receive 7.5 x 10^{-3} rem/hr with no ill effects.



Artist's Concept of SNAP-III unit.



Sectional top-view of SNAP-III prototype.

The prime contract to design and build SNAP-III was awarded to the Martin Company's Nuclear Div. by the Atomic Energy Commission in April, 1958. The aim was to produce a proof-of-principle device combining a radioisotopic heat-source with a direct energy-conversion system. The Martin Co. arranged for four separate approaches to the conversion system —two on thermoelectric devices and two on thermionic devices. On January 13, 1959, the first operating SNAP-III unit, using the thermoelectric conversion components manufactured by Minnesota Mining and Mfg. Co., was delivered to the AEC.

Source Materials—SNAP III

Heat generation in isotopic power systems results from containment of two types of radioactive materials: waste materials from controlled fission of uranium, and alpha-emitting isotopes produced by irradiating suitable target materials in reactors. Each type of source material has distinct advantages for specific missions. For space probes used for investigating electro-magnetic radiation, alpha-emitters are used. On the basis of potential availability, cost and the lack of hard gamma radiation, only four isotopes were chosen as heat sources. These are Curium-242, Polonium-210, Curium-244, and Plutonium-238. Curium-242 and Polonium-210 are in the short-life, highpower category; Plutonium-238 has an 86.4-yr half-life suitable for long-lived heat sources; Curium-244 with a 17.9-yr half-life will serve for intermediate applications.

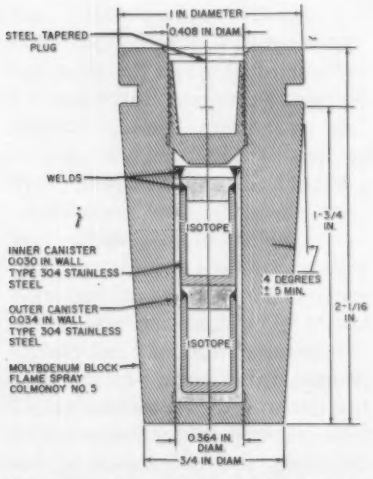
Biological hazards to consider in building radioisotope heat sources are: (1) Direct radiation hazard from alpha and beta decay, alpha-neutron reactions, and gamma photons from decay products and fuel impurities. (2) Potential hazard from possibility of the radionuclides dispersing, and assimilation by humans through inhalation and ingestion. To assure safe containment

Space Power

Are Isotopic Sources The Answer?

under all anticipated conditions, the source material is sealed in capsules of high-temperature, high-strength materials.

Polonium-210 for SNAP-III was supplied in encapsulated form by the Mound Laboratories. Each of the two stainless steel cylinders contained about 800 curies of activity, and was closed with a tapered plug. The plug was sealed by heliarc welding with 100 per cent penetration. Each capsule was carefully tested for alpha activity and helium leakage. The two cylinders were inserted into a close-fitting third canister, which was sealed and tested using the same techniques. The third canister was enclosed in a molybdenum core which had been flame-coated to prevent oxidation and sealed with a stainless-steel tapered-pin plug under helium pressure. The latter provides a thermal bond between the steel capsule and the molybdenum core. Closure with a pin plug obviates the need for a high-temperature seal which could affect the heliarc welds adversely. Tapering the molybdenum block insures good thermal contact with the hot-junction ring of the thermoelectric converter.



Cross section of SNAP-III isotope containers is shown.

SNAP-III-B CHARACTERISTICS

Dimensions	**4.75 in. diam; 5.5 in. high**
Weight	**4 lb**
Source	**1700 curies (0.38 gm) of Polonium-210**
Thermal output	**60 w**
Electrical output	**3.3 w to optimum load of 1.7 ohms**
Efficiency	**5.5%**
Total electrical power output over 280 days (approx. 2 half-lives)	**10,000 w-hr**
Conventional battery equivalent (over 2 half-lives)	**160 lb of zinc-silver cells**
Open-circuit voltage	**5.0 v**
Closed-circuit voltage	**2.5 v to 1.7 ohm load**
Thermoelectric elements	**lead teluride: P-type doped with bismuth, N-type doped with sodium**
Hot junction temperature	**496° C**
Cold junction temperature	**107 °C**
Copper shell temperature	**99° C**
Dose rate at shell surface	**500 mr/hr**
Dose rate at 1 foot	**50 mr/hr**
Dose rate at 5 feet	**1 mr/hr**

Note: Performance data are for unit at beginning of first half-life of Polonium-210 source.

Thermocouple Design

Situated radially about the contained heat source are 27 couples of doped lead telluride elements supplied by Minnesota Mining and Manufacturing Co. These elements are doped with bismuth or sodium to provide N- and P-type semiconductors, with one N-type and P-type thermoelement defining a couple, and all connected in series. Each of the elements provides a parallel path for heat flow from the heat source to the container-radiator.

Since the thermocouples must be electrically insulated from each other, mica sheet or a ceramic coating is used between the hot junction and the heat source. At the cold junction terminus an alumina coating process, called Martin Hard Coat, provides a thin, electrically insulated thermal path to the container-radiator. Each of these elements is spring-loaded at the cold-junction side to insure positive, low-resistance electrical contact at the hot and cold junction.

The adjoining table lists the important performance characteristics of the SNAP-III-B unit. However, this device was constructed for "proof-of-principle" and little attempt was made to minimize weight.

Advanced Studies

Extensive work is in progress on more advanced isotopic-power systems to produce auxiliary power with markedly greater weight savings. Some of these advanced systems will use the thermionic effect to convert the heat from the radioisotope fuel into electrical power. It is anticipated that safely packaged isotopic power supplies can be built during the next few years to produce eight watts per pound and to operate at significantly higher efficiencies than the five or six per cent achieved by SNAP-III-B.

Based on a paper by Dr. William W. T. Crane, presented before The International Astronautical Federation Meeting, 1959, London, England.

✦

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Generator: Delivers 300 watts average; 600 watts peak, 40 kc.

Transducer: Barium Titanate, 40 kc. Diaphragm, 112 sq. inches.

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Valves: Pushbutton, solenoid-operated on all drains.

Cabinet: Cold rolled steel, baked enamel finish; 16 gauge, 302 stainless steel top. (All stainless steel cabinet optional at extra cost.) Over-all dimensions, 56" long x 32" high x 23½" wide.

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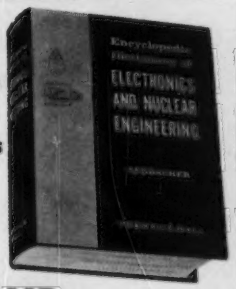

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TEST STAND for liquid hydrogen rocket is located at Pratt & Whitney Aircraft's Florida R&D Center. Large firing tubes create vacuum space conditions.

Materials Selection for the Hydrogen Rocket

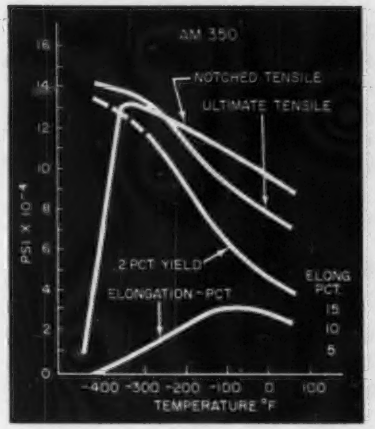
Lack of Data Plagues Designers, Temperatures Range From —423 to 6000°F; Existing Procedures Inadequate For Testing Ductility; Plastic Strain In Metals New Area For Rocket Research

by Lionel Arcand, Pratt & Whitney Aircraft
Florida Research & Development Center

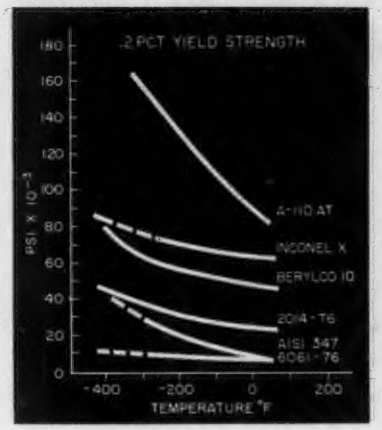
The liquid hydrogen rocket will deliver about 40 per cent more power than is possible with an equivalent amount of fuels currently used. Designated XLR 115-P-1, it is being designed and built by Pratt & Whitney Aircraft at its Florida R&D Center. Used with Centaur, it will be capable of putting a 7500 lb satellite in a 300-mi high orbit. As the third stage of Saturn, it will aid in lifting multiton loads into orbit or deep space.

Liquid hydrogen is being piped about one half mile, from plant to test site in Florida. Storage is in double-walled Dewar tanks. Many of the materials problems of extreme temperatures are just unfolding.

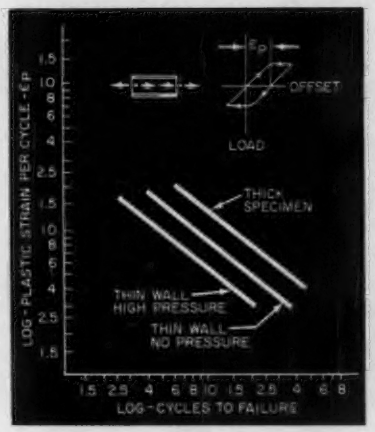
Less than one inch of engine structure separates temperatures of –423 and 5500°F in the liquid hydrogen rocket. That is a spread of 6423°F. Even to the nonexpert in extreme temperatures, this gives some measure of magnitude to the structural and materials challenge that Pratt & Whitney's (P & W) Florida R & D Center is facing. This group is laying the ground work for U. S.'s first liquid hydrogen rocket.



Properties of AM 350 stainless steel are shown. Notch-bar strength vs. ultimate tensile strength is used to get useful ductility range.



Titanium displays surprising cryogenic properties. Ductility is good, as shown. Some alloys double room temperature strength.



Effect of plastic strain is shown for thin-walled cylinders with and without internal pressure, as well as for thick-walled cylinders.

Cooling Tubes and Nozzle

Typical structural and material problems are found in the thrust chamber and its cooling tubes.

Weight is always a problem in rocket design. The cooling tubes must therefore have minimum wall thickness. But, they must also be strong at high temperatures, and ductile at low temperatures. Liquid hydrogen is passed through the tubes to lower the wall temperatures of the chamber. The outside of the chamber is thus at cryogenic temperature while the inside is extremely hot from being in contact with the hot and expanding gases.

The nozzle also has a high expansion ratio. Tubes must, therefore, be capable of severe forming and tapering to match the nozzle shape. This is all topped off by the requirement that the tubes be made of an alloy that is easily brazed.

Materials which meet these requirements are few. P&W chose AISI 347. High ductility at low temperatures, excellent braze ability, and its superior low temperature properties were the governing factors.

Forming the tubes to the severe taper is done by a spin-drawing. Need for high dimensional and quality standards is clear since each 0.001 in. of wall thickness is reflected directly in pounds of engine weight, and in a possible change in chamber heat sink characteristics. Quality of the tubes matches that necessary for a nuclear application.

Plastic fatigue of the nozzle is another structural problem of major importance. The 6423°F temperature difference results in thermal stresses which carry the hot side of the tube into the plastic region each time the rocket is fired. The tube also carries a high internal pressure, in the hoop plane. Since these longitudinal stresses are carried through the plastic region, the number of cycles, or firings, which can be allowed is greatly reduced.

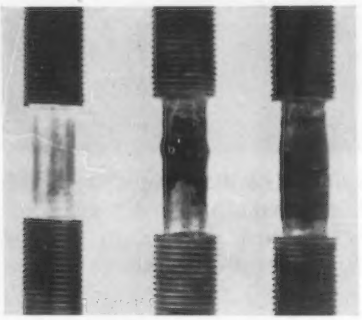
Need for Structural Data

Although the problem has been treated in the literature, none of the published data deals directly

EXTREME COLD (–423°F) causes special materials engineering problems. Liquid hydrogen feed lines, pump, and valve are shown.

Rocket Materials

AISI 347 steel for cooling tubes; Titanium gives testers surprise



PLASTIC STRAIN causes parts to fail. Shown are test specimens of tubes which make up thrust chamber. Left, prior to test, center, after 1200°F with internal pressures; right, after 1500°F with internal pressure.

with the plastic straining of a thin wall cylinder under internal pressure loading. P&W was forced to do extensive research on plastic strain cycling. Preliminary conclusions are:

- Thin walled cylinders have a lower cycle life than published data shows.
- High internal pressure greatly lowers the cycle life.

Longitudinal stress exceeds the critical buckling stress and a ridge or ripple emerges when a thin walled cylinder is strained axially. This occurs more readily when the hoop stresses are sufficiently high (approaching the yield). Subsequent tensile and compressive straining accentuate the ripple until failure occurs. Failures usually occur in a circumferential plane. The original buckling in the hoop and plane results in a thinned wall, and local strain intensification takes place. In some cases this has lowered the structure cycle life by a factor of three.

Best materials in plastic strain fatigue are generally those with the highest ductility at test temperature. Just as important is the coefficient of thermal expansion of the material. A low coefficient results in lower strains and longer cycle life. The accompanying illustrations show an unstrained specimen, one strained at 1200°F, one at 1500°F. Both carried internal pressure.

Materials For Cryogenics

Choice of materials for the extremely low temperatures has been difficult because of the sparsity of data. Most metals show a higher strength and modulus of elasticity at low temperatures. Unfortunately, many alloys show a great increase in brittleness at low temperatures.

Charpy impact test is used as the criteria for ductility in all data assembled for low temperatures. Although this test shows the ductile-to-brittle transition temperature, the transition is not always sharp and may be spread over 150 to 200°F. Another short coming is that the impact tests give an indication of relative ductility. This is of

THRUST CHAMBER DESIGN of XLR-115 is shown in experimental construction shop. Tubes which make up thrust chamber are AISI 347 steel. Strength, ductility, and brazeability govern its use.

20,000 LB THRUST engine will power Centaur and third stage of Saturn. Test firings have been made at P&W's Florida R&D site. Turbopump cycle uses "bootstrap" action for better efficiency.

little use to the designer. With this data alone, it is almost impossible to assign a reasonable allowable impact strength beyond which a material can be used. For this reason, impact testing has taken a back seat in low temperature material studies at P&W.

Notched-bar strength versus ultimate strengths is used to evaluate materials. When the gap between the two narrows, useful ductility is decreasing and a limit is drawn (see Fig. 1 for AM350). In all cases, the notched-bar strength must exceed the ultimate tensile strain of the alloy.

Results Surprising

Test results have been surprising. Stainless steel and high nickel alloys are strong and ductile at low temperatures (as suspected). But the performance of titanium alloys is amazing. Ti 6AL-4V and A110AT actually double their room temperature strength at cryogenic temperatures while maintaining useful ductility.

Cast aluminum is used in the rocket engine gear boxes and pump housing. Aluminum is the obvious choice in these cases because its weight to section-modulus ratio provides a light deflection-free structure. Most aluminum alloys benefit from cryogenic temperatures in strength and modulus increases, showing no appreciable loss in ductility. Wrought aluminum is used extensively for pump and turbine rotors. This is because stresses in a centrifugal field vary directly with specific weight, and aluminum has the highest strength-weight ratio of applicable alloys.

Inconel X and Waspalloy, the hardenable high nickel alloys, are used in cases where high strengths and modulus are required. While the age hardening alloys lose some ductility at cryogenic temperatures, the effective ductility remaining is still quite high at –420°F.

Beryllium-copper is used chiefly in springs and bellows. The choice of these alloys results from their high strength, good ductility and low modulus of elasticity. A beryllium-copper bellows, or spring with a modulus of 18×10^6 can deflect 50 per cent more than a comparable bellows whose modulus is 30×10^6 at the same stress level.

Thermal Expansion

The average coefficient of thermal expansion (or contraction) is one of the most important physical properties needed by a designer, yet very little low temperature data is available.

Data on pure metal like copper, zinc, and aluminum has been published, as well as information on a number of stainless steels and nickel alloys. However, virtually nothing has been reported at temperatures below –320°F, and very little from –320°F to –100°F. This is particularly true of the common structural alloys. Therefore, P&W again set out to acquire its own low-temperature thermal-coefficient data.

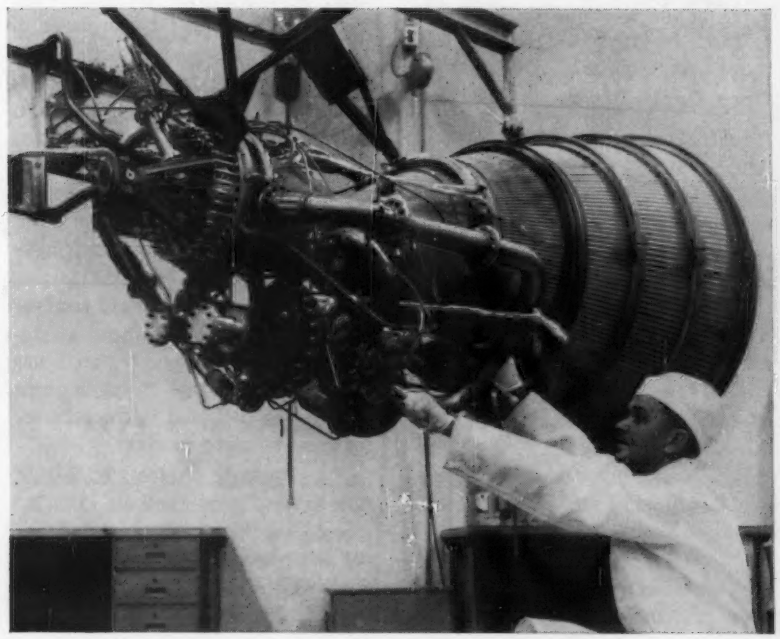
Explosive Combinations

Liquid oxygen will explosively combine with a great number of compounds, particularly hydrocarbons. An impact tester is used to check lox compatibility of materials. A small aluminum cup is filled with liquid oxygen and the sample material. A weight with a predetermined potential energy is released by a solenoid and impacts on the specimen. An explosion of varying degree may result. A material which detonates or flashes once in 20 drops is considered incompatible.

This test can be misleading, careful interpretation of the data is required. An additional test has been devised which will rub different surfaces together in liquid oxygen at various speeds and loads. This test will give a more realistic meaning to lox compatibility.

✦

FIRST DETAILS OF XLR-115 show position of turbopumps and other engine accessories. It is essential that grease be kept away from LOX ducts, hence final inspector wears white gloves, coat, hat. "Bootstrapping" pumps eliminates the need for an auxiliary gas generator.



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Cryogenics Boost Infrared Detection

Cooling of Detector Head With Liquid Nitrogen Increases Response to Long Wavelengths; Open-Cycle Design of Cooling System Is Simple and Reliable

by Philip Geddes

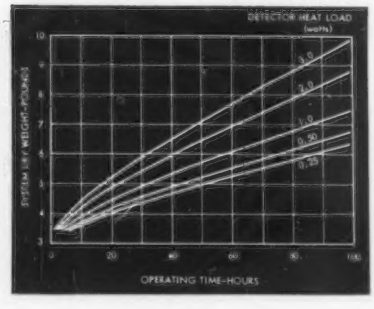
New infrared materials give a broader detection range and higher efficiency when cooled to cryogenic temperatures. Use of infrared for guidance, surveillance, and other military applications will be enhanced by these materials.

Advanced Cooling Systems for detector materials are now in production at Garrett Corp.'s AiResearch Mfg. Co. They are basically simple in makeup and operation. Main items are:

- Cryogenic liquid.
- Cryogenic liquid container.
- Transfer tube.
- Detector cell liquid receiver.

Systems are designed to maintain the liquid receiver element at the temperature of liquid nitrogen. Advantages of simplicity and no external power requirements afford high reliability.

Fig. 1. Total system weight vs. operating time for a typical liquid nitrogen cooling system is shown.



Design variables of a particular cooling system are: (1) Heat load, (2) Operating time, (3) Standby time, (4) Ambient temperature and pressure, (5) Length of transfer line, (6) Cooling temperature and tolerances, (7) Detector head configuration.

Fig. 1 indicates the total system weight versus total operating time and capacity for a typical liquid nitrogen infrared detector cooling system. As an example, a single search detector load of one watt, operating for 100 hr would require a system weight of only 7.6 lb and a capacity of 5.9 liters.

Open Cycle Design

The AirResearch infrared detector cooling system is of open cycle design. The system consists of a liquid nitrogen storage container coupled with dual phase flow-transfer lines (liquid/vapor), detector heat liquid receiver, and necessary controls. Typical functional schematic is shown in Fig. 2. Closed cycle refrigeration circuits were also studied. It was concluded that for present applications requiring up to 100 hr operating periods, the liquid system results in the simplest, lightest, most reliable package.

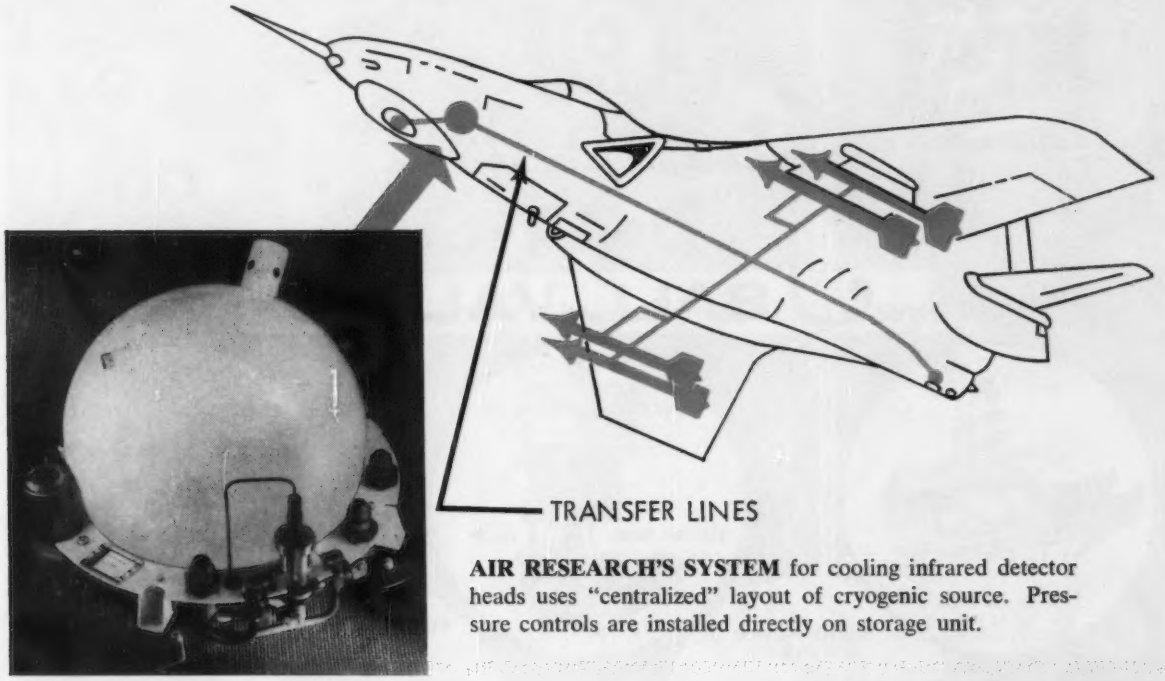
Relative response of several infrared detectors in terms of minimum detectable power is shown in Fig. 3. It can be seen that cooling results in a greater degree of response in the detection of long wave length signals. An open cycle cooling system makes possible the detection of lower temperature subjects, and permits the operation of infrared detectors in the more optimum transmission spectra portion of the atmosphere.

Liquid System Components

Cryogenic liquid containers range in capacity from less than one liter to 86 liters. Containers are of dual wall, stainless steel construction. Special support techniques are used to minimize heat transfer from the ambient to the inner container. The dual phase flow transfer lines require no insulation. This adds to system simplicity. Lines are sized to establish fluid velocities which result in the best transfer efficiency. Efficiencies as high as 50 per cent, and transfer distances of 25 ft have been accomplished.

Design of the liquid receiver in the infrared detector head-assembly must be carefully integrated into the system. Liquid nitrogen must actually be collected in the receiver for most efficient cooling.

Pressure controls to induce flow to the detector cell are installed directly on the storage vessel. Manual or remotely operated automatic controls start and stop system operation. Temperature regulator con-



AIR RESEARCH'S SYSTEM for cooling infrared detector heads uses "centralized" layout of cryogenic source. Pressure controls are installed directly on storage unit.

trols can be installed when it is desirable to maintain detector head temperatures above that of liquid nitrogen.

Suggested System Layout

Experience suggests a centralized location of the storage unit, with dual phase liquid transfer lines connected to remotely located infrared detector units. A search detector, a warning detector, and several infrared-guided missiles can be served by one central cooling system.

Evident advantages of this type layout are:

- Efficient integration of all cooling requirements.
- Single ground service point.
- Utilization of available space.
- Control flexibility.
- Lower total system weight and bulk.
- Fewer components.

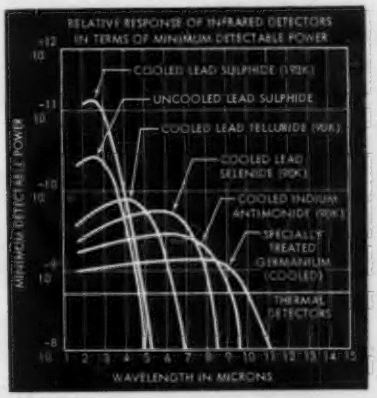

RELATIVE RESPONSE OF INFRARED DETECTORS IN TERMS OF MINIMUM DETECTABLE POWER
COOLED LEAD SULPHIDE (193K)
UNCOOLED LEAD SULPHIDE
COOLED LEAD TELLURIDE (90K)
COOLED LEAD SELENIDE (90K)
COOLED INDIUM ANTIMONIDE (90K)
SPECIALLY TREATED GERMANIUM (COOLED)
THERMAL DETECTORS
MINIMUM DETECTABLE POWER
WAVELENGTH IN MICRONS

Fig. 3. Relative response of several detector materials is shown. Cooling gives obvious advantages.

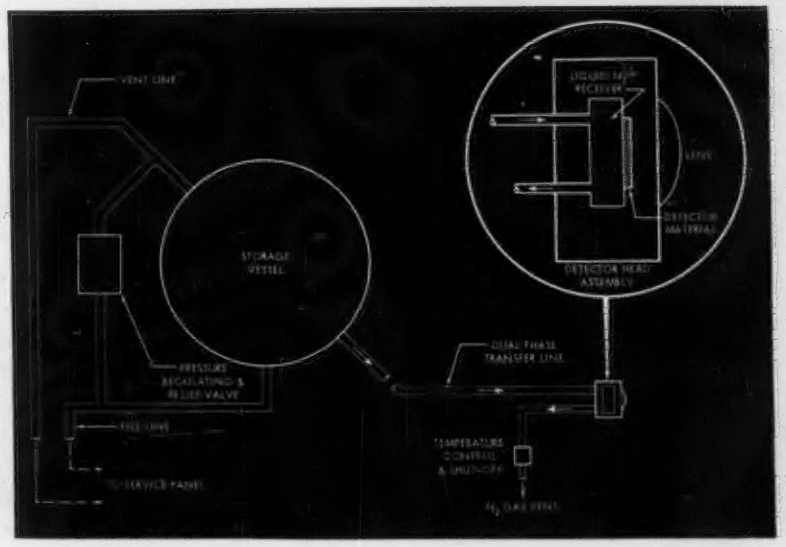


Fig. 2. Schematic shows open cycle design. It is judged most effective for 100 hr operating periods.

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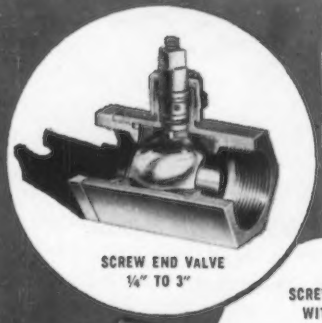

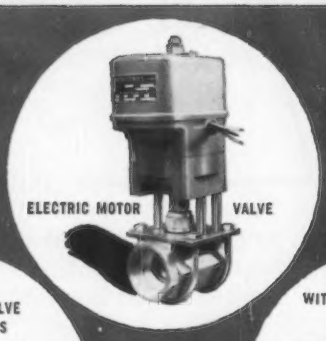

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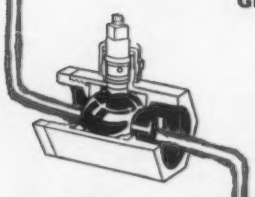

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MOIRE FRINGE EFFECT . . .

A Simple Method for Measuring Motion

Slight Deflections "Magnified" by Observing Motion Through Angled Slot; Principle Useful in Structural Test And Instrument Calibration; Electronic Devices Make System Automatic

By Ronald A. Cole

It is possible to detect the small movements of a body by viewing a line scribed upon it through a skew slot. The resulting apparent magnification of movement depends on angle between the slot and the line. This principle is illustrated adjacently. It is shown that a small movement of line AB to position A′B′ causes a large vertical shift of position across the slot. This shift can be expressed trigonometrically as follows:

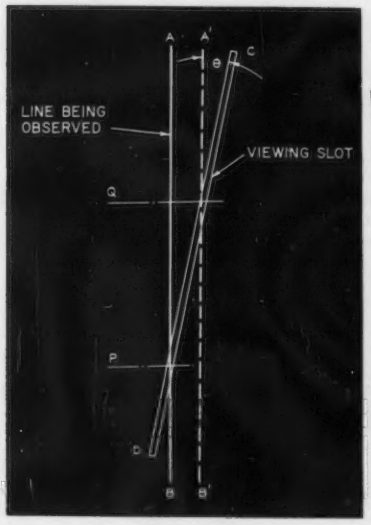
PQ = (AA′) cotangent θ

If θ = 1/2 deg
PQ = 115 (AA′)

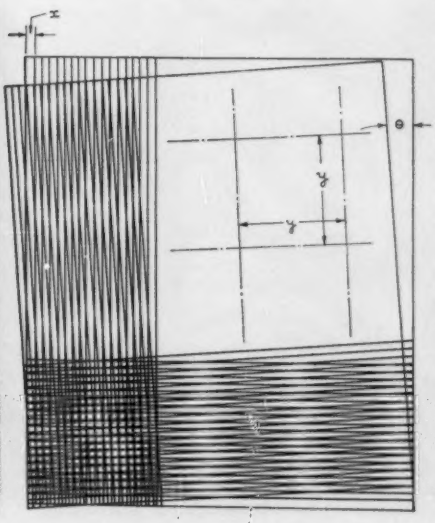
If θ = 1/5 deg
PQ = 287 (AA′)

Thus, for small but practical angles, the magnification is sufficient to make a very small deflection plainly visible. The smaller the angle θ is, the greater the magnification. It is also obvious that the apparent displacement is at right angles to the actual movement.

LINE-AND-SLOT effect is basic mechanism of Moire Fringe principle.



MOIRE FRINGE effect obtained with superimposed grids having lines ruled in two directions.



Where It Can Be Used

This simple concept is being used for measuring structural deflections and observing vibrational modes. Possibly, this idea may provide a major breakthrough in stress and vibration analysis. Cheaper and quicker to operate than strain gauges, the system could be made to yield direct readings of major strain and its direction. Basic R & D work is being carried out by The Royal Aircraft Establishment at Farnborough, England, and patents are pending to the Ministry of Supply.

In the actual application, the slot and line setup is replaced by finely-ruled square grids. By superimposing these, at a slight angle θ to each other, a Moire Fringe Pattern is formed. The pattern consists of vertical and horizontal dark bands forming squares that are very large compared with those ruled on grids.

Movement of one grid relative to the other causes the fringe pattern to move also, but at 90 deg to it. Actual displacement is equal to the original movement multiplied by cotangent of angle between grids.

By affixing one grid to a test structure, and the other to a fixed reference, it is possible to read de-

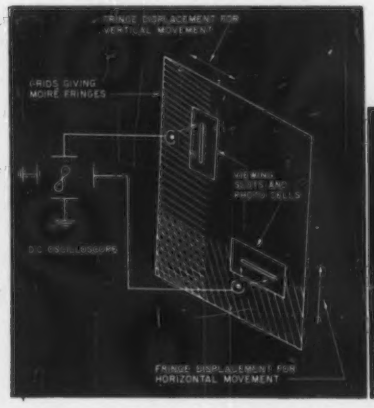
Moire Fringe Effect

flection and study the path traced. The latter feature is very useful in studying complex vibration problems. By observing movement visually, the engineer can make immediate adjustments. Positions of ultimate and allowable deflections may be marked on a reference plane and the specimen quickly loaded to that point.

How Grids Are Made

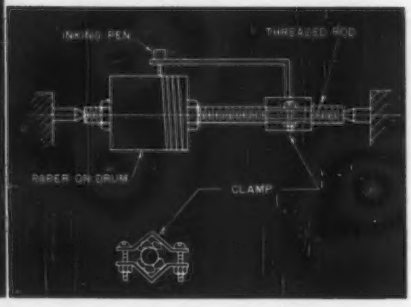
Grids may be engraved on glass or plastic, or they may be printed on cellophane and mounted on any transparent material. Thin plastic sheet has been successfully used to make grids about ½ in.^{2} It is thought that suitable sizes are between 1 and 5 cm^2; they could be made smaller and viewed through lenses. Line spacing at 1/5 mm is typical, and ideally the lines should be as thick as the space between them. The closer the lines are, the better the sensitivity of the device.

Change of density across square pattern is independent of line spacing. If grids are closely ruled and the inclination between them is small, then the fringe pattern density is in accordance with (1—cosine) law. It is, therefore, possible to use photoelectric cells to give remote and automatic detection of displacements.

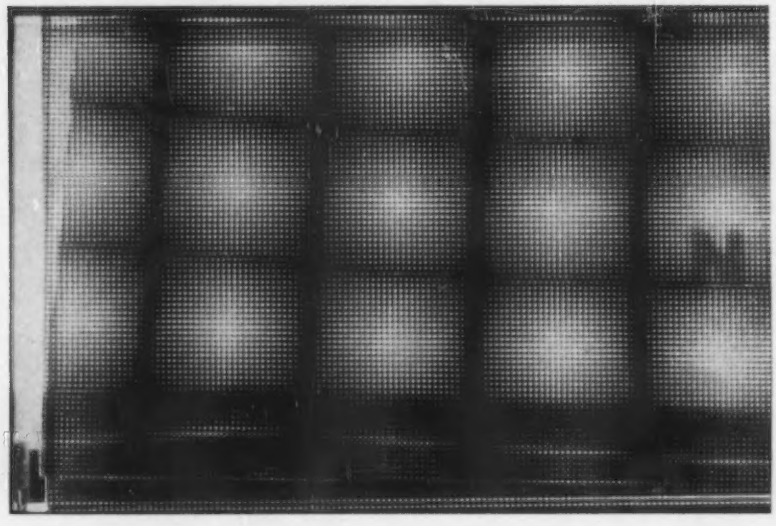


AUTOMATIC DETECTION of movement is possible using oscilloscope.

MECHANICAL DEVICE speeds ruling of grid lines.



LARGE FRINGE PATTERN (illuminated from behind) is shown set up for demonstration purposes in actual photographs. Curvature of horizontal fringe lines is caused by lens distortion.



Oscilloscope May Be Used

A simplified set-up diagram is shown incorporating a d.c. oscilloscope. Here, the spot of a cathode ray tube would plot the displacement of the pattern. This method would give valid readings for all types of deflection, including those having a torsion component. There would be little difficulty in employing telemetry apparatus instead of the d.c. oscilloscope, for tests on missiles.

In application, grids must be parallel and close to each other. Where it is not possible to get them close, a lens arrangement may be used to project one onto the plane of the other. If this fringe pattern method is applied to the study of a structure that deflects and rotates, then special care is needed in interpreting results. As one grid rotates with structure, the incident angle θ will change, therefore magnification will also change. The difference between initial and final dimensions of fringe pattern will be a measure of the torsional strain.

Magnification is always determinable, for it is the ratio of the size of the square pattern to the squares ruled on the grids. This is known for any grid system, and the actual squared pattern obtained can be measured. Since it is possible to illuminate the patterns from behind, it is possible to arrange camera recording of pattern movement and track. There is some error in pattern measurement, since there is not a definite sharp line to register against. Despite this, accuracy to within ± 10 per cent has been obtained in practice.

✦

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"The Fall of Icarus", by the 18th century illustrator Picart, is an imaginative conception, based on Greek mythology, of space propulsion by muscle power. This interpretation of it by wood engraving is one in a series of similar works undertaken especially for Hercules by Brussel-Smith, noted graphic artist.

IMAGINATION IN SPACE

Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

This, then, is the working philosophy of Hercules in chemical propulsion: To design and manufacture highly concentrated packages of energy as propellants and rocket motors; each compatible, controllable, predictable; and each perfected for its specific mission.

HERCULES' BACKGROUND: A half-century of creative imagination in the evolution of propellants, from shotgun powder to space propulsion; encompassing research, design, engineering, and staff organization for the production of the most advanced propellants.

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Circle 16 on Inquiry Card

Optical Synchro Systems

Errors Caused by Structural Flexing Are Eliminated, This Eases Calibration and Gives Great Versatility; Applications in Space Guidance, Launch, Production Seen

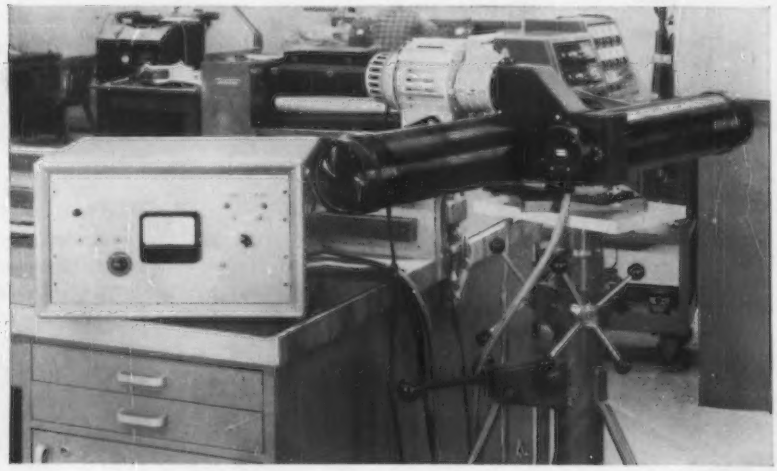
by **Robert O. Wyne,** Chrysler Corp., Missile Div.

Transmission of angles, within a few seconds of arc, is a characteristic requirement for missile-guidance and space-vehicle navigation systems. Applications may range from the rapid aiming of small, mobile artillery missiles to the transfer of angles through space.

Electrical synchronous transmission systems have accuracies now approaching a few seconds of arc. However, electrical synchros suffer from some basic disadvantages; one of these is the problem of initial calibration of the system. Quite often, the accurate alignment of the electro-mechanical null is a costly and time-consuming process. This is because electrical synchros must be referenced to a rigid reference frame; that is, stationary parts of synchros must be attached to a non-flexible body, to achieve accurate transmission of shaft angles. If synchro cases are referenced to a non-rigid member, such as an aircraft or ship structure, transmission angles will be in error by the amount of flexure of the intermediate structure. These errors sometimes become quite large.

Chrysler Corp. first became interested in this problem when it was prime contractor for the Fleet Ballistic Missile System in 1956. At this time, the requirement was to transmit an accurate azimuth reference angle from the ship's inertial navigation system, to a remotely-located missile stable-platform. It was proposed to solve this problem using a highly-accurate electrical synchronous transformer system, together with optically monitoring the flexure angle of the ship. Optical monitoring was to be continuous, and error signals thus generated were to be fed back into the electrical synchro system, as error correction for flexural angle. A survey of available optical instruments, to measure this flexure or error angle, revealed that they suffered from one basic drawback. They were sensitive to vibration, and would not measure accurately under conditions encountered by a ship at sea. Chrysler, therefore, undertook the development of an instrument which would fulfill such operational requirements.

Fig. 1. Optical synchro system was developed by Chrysler Corp., Missile Div., to transmit azimuth reference angle from a ship's inertial navigation system to a remote missile stable-platform.



Good for Vibration Environment

The instrument shown in Fig. 1 is the result of this development. It utilizes a dynamic measuring technique, and is not subject to errors caused by a vibration environment. This instrument was installed and operated on the U. S. S. Compass Island, measuring the angle of flexure between one end of the ship and the other. About this time, responsibility was transferred for the Fleet Ballistic Missile System and the project was discontinued.

Development had progressed, however, to a point where it was seen that tremendous advantages would accrue if a purely-optical synchro system could be found to replace the electrical synchro and optical monitoring scheme. The system represented schematically in

Fig. 2 is a result of this development effort.

Light originates at the source, passes through a condensing lens system, and falls upon a rotating polaroid disc. This causes the light past the rotating polaroid to be plane polarized.

The rotating polarization plan is represented in Fig. 3 by the single black vector. The vector rotates at constant amplitude, or light intensity, at twice the speed of the chopper motor.

As shown in Fig. 2, rotating polarization plane falls upon a calcite crystal which has the property of bi-refringence. This is the ability to resolve a polarization plane into two components which lie upon the fast and slow axes of the calcite crystal. These axes are normal to each other.

Thus, light intensities in the two planes of polarization, as they emerge from the calcite crystal, are pulsating sinusoidally as the main polarized vector rotates. These pulsations are 180 deg out of phase with each other. As the newly-resolved polarization planes pass through calcite crystals, they strike a beam splitter, are reflected through an objective lens system, and leave the instrument.

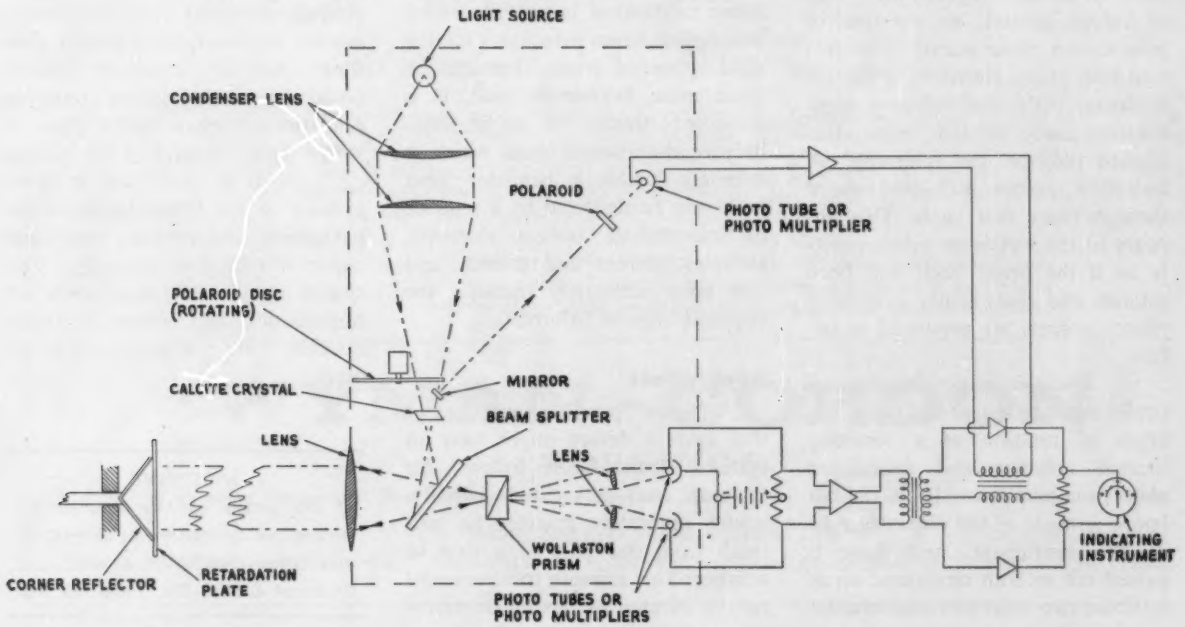
Bridge Circuit Used

Let us imagine now that the beam strikes a plane mirror positioned exactly normal to optical axes of objective lens. Light is returned through the objective system, through the beam splitter, and falls upon a wollaston prism. The wollaston prism is also bi-refringent, and in addition, it physically separates the resolved vector quantities of polarized light into two emerging light beams. Each light beam passer through another lens system, and falls upon a photo tube. The wollaston axes, shown in Fig. 4, are mechanically oriented at 45 deg to the axes of the calcite crystal. As the calcite crystal's vector quantities are resolved by the wollaston prism, the vertical components equal the horizontal components for any position of the main polarization plane. A steady d.c. signal will appear at each photo tube located in arms of bridge circuit. Hence, as long as the wolloston prism's axes are at 45 deg to the axes of the calcite crystal, no current will flow in the bridge.

If the wollaston prism is rotated slightly, so that axes are now in position shown in Fig. 5, the steady-state or null condition is no longer satisfied. That is, vertical components of the light, leaving the wollaston prism, are no longer equal to the horizontal components. As the primary polarization plane rotates, these vectors fluctuate sinusoidally with respect to each other, and sinusoidally modulated d.c. photo current appears in each arm of the bridge. These modulations are in phase opposition and operate in push-pull across the bridge circuit. Signal is amplified, transformer passes a.c. components into phase-detector circuit, and output microammeter indicates amplitude of a.c. signal.

A reference voltage is introduced into the phase detector circuit, to determine direction of rotation of wollaston prism. This reference voltage is generated by diverting some of the original light, past the rotating polaroid disc, through a polaroid analyzer to a photo tube. This results in an alternating reference voltage at the phase detector. This signal is either in phase or 180 deg out of phase with

Fig. 2. Schematic diagram of optical synchro transmission system is shown.



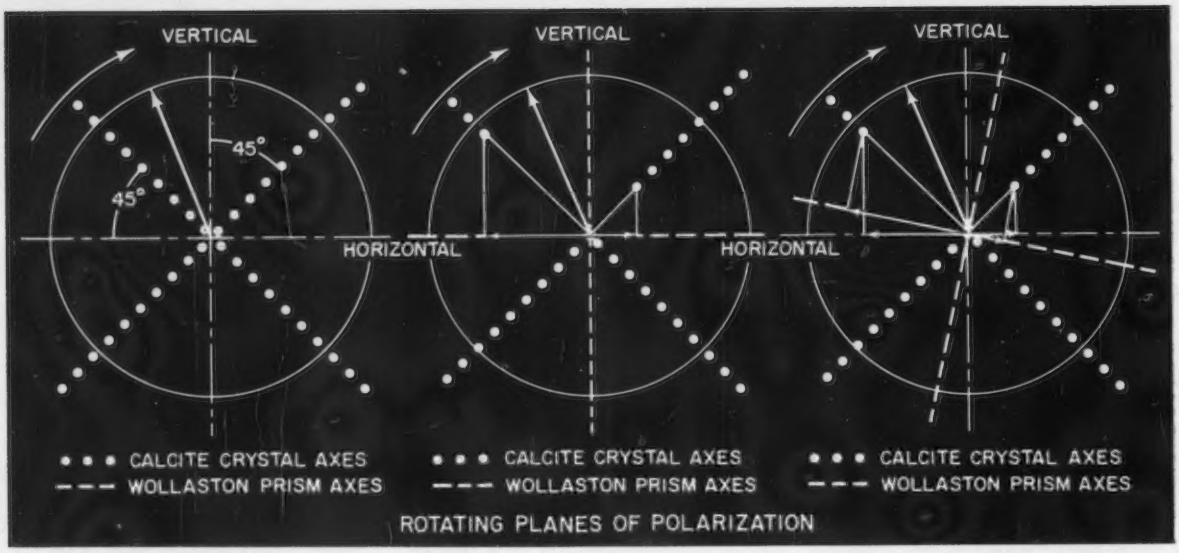


Fig. 3. Vector shown as heavy arrow represents the rotating plane of polarization.

Fig. 4. Vertical and lateral vectors are equal for any position of main polarization plane.

Fig. 5. Vertical components of light, leaving prism, no longer equal the horizontal components.

the incoming signal from bridge circuit.

Light Beam Is Only Connection

So far, it has been shown that this is a method of accurately measuring rotation angle of a polarization plane. Now let us remove mirror from front of instrument and direct the outgoing light to a corner reflector, covered by a retardation or quarter wave plate. The retardation plate also has two optically-active axes. As long as these axes are aligned with axes of calcite crystal, no rotation of polarization plane occurs at the retardation plate. However, if the retardation plate and reflector combination are rotated from this aligned position, the returning polarization planes will be rotated through twice that angle. This appears to the wollaston prism exactly as if the prism itself had been rotated, and sinusoidally modulated photo currents are produced as before.

Thus, it is possible to optically measure quite accurately the angle of rotation of a remotely located reflector and retardation plate combination. If a mirror image is made of the objective tube of the instrument, and light is passed out in both directions, so as to strike two reflectors and retardation plate assemblies, the angular difference between the two may be measured. A true optical synchro system, of this type would transmit an absolute angle from one remote position to another with no connection other than a light beam.

The optical synchro system used as a highly-accurate analog angle transducer suffers from neither of the previously mentioned drawbacks of the electrical synchro system. Reflector and retardation plate components can be aligned to their respective shafts and subsequent calibration is not necessary. The optical beam substitutes for the rigid reference frame, but can be made quite flexible in itself. It is sometimes thought of as an infinitely rigid torsional beam which is infinitely flexible in bending. That is, it may be deflected by a number of intermediate optical elements, such as mirrors and prisms, and still quite accurately transmit the required angular information.

Applications

Some possible applications that such a device might have in systems of the future follow. An obvious one, as stated initially, would accurately transfer an azimuth from one part of a ship to another. This azimuth tranfer would not be affected by flexure or movement of ship between transmitting and receiving stations. This thinking can be extended to the transmission of angles aboard any vehicle which is not rigid enough for using an electrical synchro system without corrections. It might be used, for instance, in the transfer of azimuth angles from a master platform aboard an aircraft, to a missile platform remotely located on the aircraft. It might also be used for the transmission of angles from one moving vehicle to another. For instance, orientation of a fighter aircraft stabilized platform from a mother ship carrying a master platform. Azimuth alignment tranfer could be made during refueling operations when a fighter plane is within visual control of the tanker.

It is likely that in space systems of the future much of the navigation and perhaps communication will be done optically. This system could well be applied for transmission of reference angles optically from one spacecraft to another.

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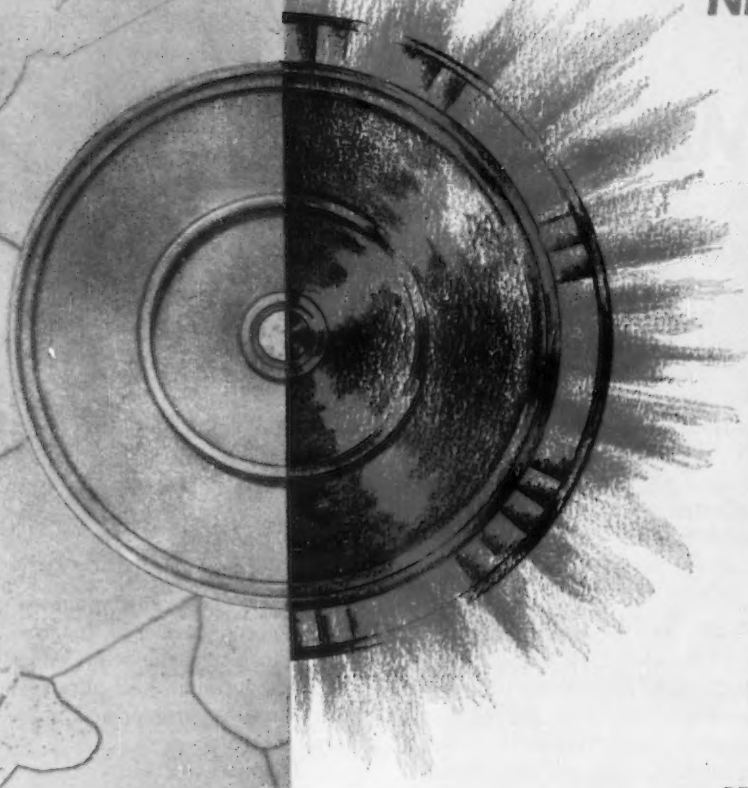

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RENÉ 41*

Typical Mechanical Properties

TENSILE PROPERTIES:	Room Temp.	1400° F
Ultimate Strength, psi	200,000	145,000
.2% Yield Strength, psi	150,000	125,000
.02% Yield Strength, psi	135,000	110,000
Elongation (% in 2")	15	18
Reduction in Area, %	18	20

STRESS RUPTURE:	Combination Smooth and Notch Bar	Smooth Bar
Temperature, ° F	1350	1650
Stress, psi	85,000	25,000
Life, Hours	100	50
Elongation, %	12	12
Reduction in Area, %	14	14

Guaranteed Minimum Mechanical Properties

TENSILE PROPERTIES:	Room Temp.	1400° F
Ultimate Strength, psi	180,000	135,000
.2% Yield Strength, psi	132,000	115,000
.02% Yield Strength, psi	120,000	100,000
Elongation (% in 2")	12	13
Reduction in Area, %	14	18

STRESS RUPTURE:	Combination Smooth and Notch Bar	Smooth Bar
Temperature, ° F	1350	1650
Stress, psi	85,000	25,000
Life, Hours	40	25
Elongation, %	8	10
Reduction in Area, %	10	12

*RENÉ 41: GENERAL ELECTRIC COMPANY

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Circle 17 on Inquiry Card

New Materials

Disogrin

Disogrin, a solid polyurethane elastomer, has proven effective as a roller-tread on ground handling equipment for Nike Hercules. The material replaced rubber which peeled off the hub in the same application.

Low deformation, resistance to scoring and galling are properties of the replacement material. **Disogrin Industries Inc.**

Circle 45 on postcard for more data

High-Density Alloy

High density Mallory 3000 is a highly workable new alloy. It can be cold-rolled and formed. Designers are not confined to machined or molded shapes.

Cold-rolled to 52 per cent reduction the alloy shows 195,000 psi OTS, 190,000 psi yield, and proportional limit of 90,000 psi. At 2000°F, short time tensile is 19,350 psi. **Mallory Metallurgical Co.**

Circle 46 on postcard for more data

Rigid Polyurethane

Gem-Foam is a pre-molded, rigid polyurethan pipe insulating material. It has properties which seem suitable for insulating piping which carries low-temp gases or liquids at missile launching sites.

Gem-Foam has a compressive strength of 50 psi at 75°F, a tensile strength of 60 psi. **Baldwin-Ehert-Hill, Inc.**

Circle 47 on postcard for more data

Super Steel

An ultra-high strength steel called USS STRUX is used as forgings in main and nose gear of A3J Vigilante. Steel has about 7 per cent more strength per unit weight than other alloys used in same applications.

Payload of Bullpup is also encased in this alloy. **U. S. Steel Corp.**

Circle 48 on postcard for more data

New Copper Alloy

Amzire, a copper-zirconium alloy, has been developed for special electrical applications. A small amount of zirconium is added to oxygen free copper to improve mechanical properties and conductivity. **Bridgeport Brass Co.**

Circle 49 on postcard for more data

Low Alloy Steel

Consutrode melting of low alloy steels gives better transverse ductility and fatigue strength. Fabricability is also enhanced for severe working operations such as spinning.

This process makes the low alloys suitable for solid propellant motor cases, gears, bearings, and piston pins. **Allegheny Ludlum Steel Corp.**

Circle 50 on postcard for more data

Black Glass

Black glass, impervious to light, has been developed for enclosing silicon semiconductors. The glass filters out almost all ultraviolet wave-lengths, visible, and near infrared spectrum.

Thermal coefficient of expansion is 92 x 10^{-7}/°C. Softening point is 675°C; and strain point is 455°C. **Corning Glass Works.**

Circle 51 on postcard for more data

Missile Cable Jacket

Okoprene jacket on multiconductor missile cables proves extremely resistant to natural and induced environments. It is one of the few sheathing materials to completely satisfy MIL-C-13777A. The product is a trade name for a specially compounded neoprene. **Okonite Co.**

Circle 52 on postcard for more data

Graphite Material

A highly oriented crystal structure is the distinguishing property of Pyrographite. It is intended as a high-temperature and electrical material.

The oriented crystals give select properties along the plane of orientation, Strength-to-weight of the graphite material in the plane of orientation is equal to 310 stainless. At 2000°C, it is 5 times greater. **Raytheon Co.**

Circle 53 on postcard for more data

Zirconia Sheets

Zirconia sheets as thin as 0.040 in. are available in 3 x 12 in. sizes.

Sheets are produced from calcia stabilized zirconia which eliminates crystalline inversion at high temperatures. Melting point is 4700°F.

Sheets can be punch pressed to special configurations. Water absorption is less than 1 per cent. Thermal shock resistance is good. **Gladding, McBean & Co.**

Circle 54 on postcard for more data

Gallium Phosphide

A rare metal called gallium phosphide may help solve the heat barrier problem encountered by electronic parts in nose cones.

The Army Signal Corps has built an electronic diode using this material. Diode withstood temperatures seven times higher than silicon and germanium, previously used in electronic diodes.

Resembling yellow ground glass, the metal was home-grown at the Signal Corps' Fort Monmouth, N. J. lab. It is still being studied to pin-point its properties before release to Signal Corps equipment development engineers. **U. S. Army Signal Research and Development Laboratory**

Circle 55 on postcard for more data

Ceramic Brick

High temperature lightweight insulating brick is of aluminum oxide, expanded and then fired. Process creates a cellular structure in which all cells are interconnected. Absorbent property permits gas to pass through for purging or evacuation.

Material has density or weight of a 1600°F insulating firebrick and an insulating value comparable to a 2300°F firebrick. It can be operated up to 3400°F and cut, sawed or filed. **Ceramic Div., Ipsen Industries**

Circle 56 on postcard for more data

Well established in special nuclear applications, BERYLLIUM METAL is now being used and tested for structural components in other industries.

High strength to weight ratio • good high temperature properties • high modulus • excellent heat sink characteristics make this light metal attractive for current and future design.

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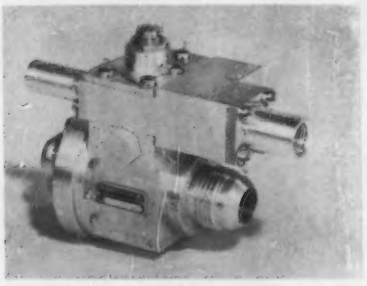
Circle 18 on Inquiry Card

New Parts and Components

Ball Valves

Low-torque "Pneu-Hydro" ball valves, operating up to 10,000 psi, may be furnished with pneumatic, hydraulic, electric or manual actuators. Unit shown weighs 1½ lbs, measures 2½ x 4¼ x 5 in. overall, has an equivalent orifice of



¾ in. and MS33656-12 ports. Models are available for handling helium, liquid oxygen, red fuming nitric acid, hydrogen peroxide as well as normal fluids used in power and propulsion equipment. **Pneu-Hydro Valve Corp.**

Circle 57 on postcard for more data

Noise Suppressor

Lightweight, portable noise suppressor has been made available for jet ground testing. Called Model AE-15, suppressor has vertical deflection feature to protect ramp personnel and eliminate erosion of ramp surfaces.

Unit is 28 ft long, eight ft wide and nine ft high. It's mounted on a lightweight, rubber-tired, undercarriage. **General Acoustics Corp.**

Circle 58 on postcard for more data

Valve Controls Freon

Light - weight, electrically-controlled, fire-extinguisher valve is announced for jet aircraft use. This is a selector valve for controlling Freon fire extinguisher fluid.

Specifications: Weight—less than 1 lb, port size ⅝ in, normally closed, operating pressure 750 psig; operating temperature — 65 to 160°F. **Marotta Valve Corp.**

Circle 59 on postcard for more data

Turbocharger

A lightweight exhaust-powered turbocharger has been adapted to the new Franklin 6VS-335 helicopter engine. Turbocharger weighing 26 lbs enables engine to maintain its sea level rating of 225 hp up to an altitude of 15,000 ft.

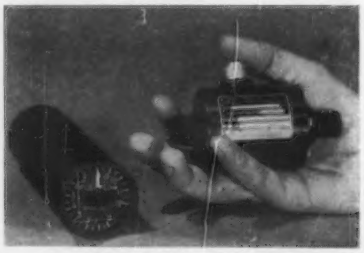
Turbocharging kits are also available for other similar engines already in operation.

F.A.A. approval of the turbocharged engine has been received. **Garrett Corp.**

Circle 60 on postcard for more data

Mass Flowmeter

Miniature mass flowmeter system for small aircraft has a transmitter that incorporates only two moving parts.



Consisting of a flowmeter transmitter and flow-rate indicator, system measures fuel flow rate by mass rather than volume.

Cylindrical in shape, it is about three in. long and two in. in diam. Total weight, including both transmitter and indicator, is about two lb. Normal range involves flow rates up to 1200 pph. **General Electric Co.**

Circle 61 on postcard for more data

Mount For Wing Lights

Vibration - isolating mount for wing-tip lights on military and commercial aircraft. Designated

Model K1092, mount incorporates stainless-steel resilient cushions in an all-metal design. Anti-rotation feature is also incorporated to assure socket stability during installation and removal of bulbs. **Robinson Technical Products**

Circle 62 on postcard for more data

Gear Pump Series

Gear pumps give 3000 psi constant pressure and 4500 intermittent pressure service. They deliver uniform flow regardless of variations in fluid viscosity or load, and have capacities of 5, 10, 15, or 30 gpm. Special pumps with capacities up to 100 gpm are available on order.

Needle bearings are contained in a pair of one piece bearing block; will not misalign under loads. This construction assures precision alignment of both gears and needle bearings at all operating pressures. **Superior Hydraulics div. of Superior Pipe Specialties Co.**

Circle 63 on postcard for more data

X-15 Shutoff Valves

High response shut off valves contribute to the safe operation of the X-15.

A pair of butterfly valves, three inches in diameter, is used in the fuel system to jettison all surplus propellant prior to the X-15's

landing. A similar pair, five inches in diameter, serve as rapid shut off valves to stop flow of fuel into the combustion chamber in the event of malfunction.

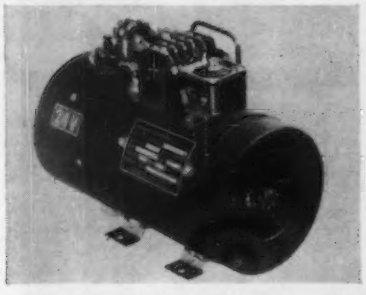
Both valves are metered to respond in 600 milliseconds without allowing surge pressures to exceed 60 psi and possibly aborting the system. Flow velocities within the three and five inch valves are 25 and 16 ft per sec. respectively.

For dual use, one valve handles ammonia and one handles liquid oxygen. The valves are required to withstand steady temperatures ranging from 165° to —320°F. They must also withstand thermal shock up to 590°F. **Stratos Div, Western Branch Fairchild Engine & Airplane**

Circle 64 on postcard for more data

Forced-Air Heater

A 15,000 BTU/hr forced-air heater, measuring 5½ in. x



10⅜ in., may be used as an engine pre-heater. Unit weighs less than 10 lb, and can be easily installed in any position. Special combustion is claimed to insure instantaneous ignition even at sub-zero temperatures, while pre-vaporization of fuel is said to prevent formation of clogging deposits on burner. Operates on all common liquid fuels (including Diesel and JP-4), and can be equipped for either manual or thermostatic control. **Benmar Co.**

Circle 65 on postcard for more data

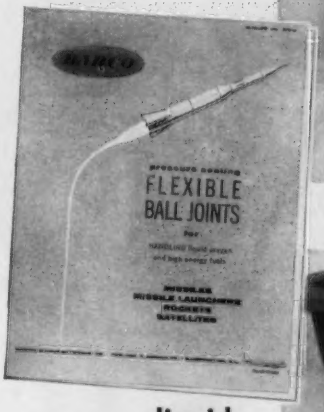
Microphone Transducer

Water-cooled microphone transducer (model 752) was developed for measuring high level sounds under severe environmental

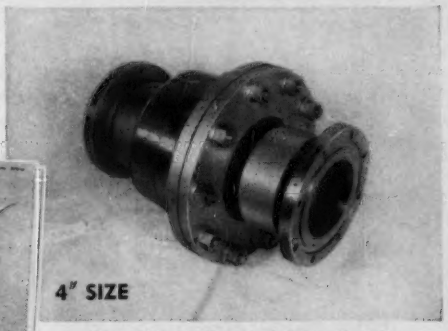
continued on page 51

BARCO FLEXIBLE JOINTS

For Handling High Energy Fuels . . . .



. . . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel



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180° flanged 6" Barco Ball Joint for use in loading and unloading line handling liquid propellant.

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—**Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300°F. Also high temperature designs up to +1000°F.**

—**Special designs resistant to nuclear energy radiation.**

Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

Flexible Hydraulic Lines for Missiles, Aircraft

MISSILE LAUNCHER HYDRAULIC ASSEMBLY

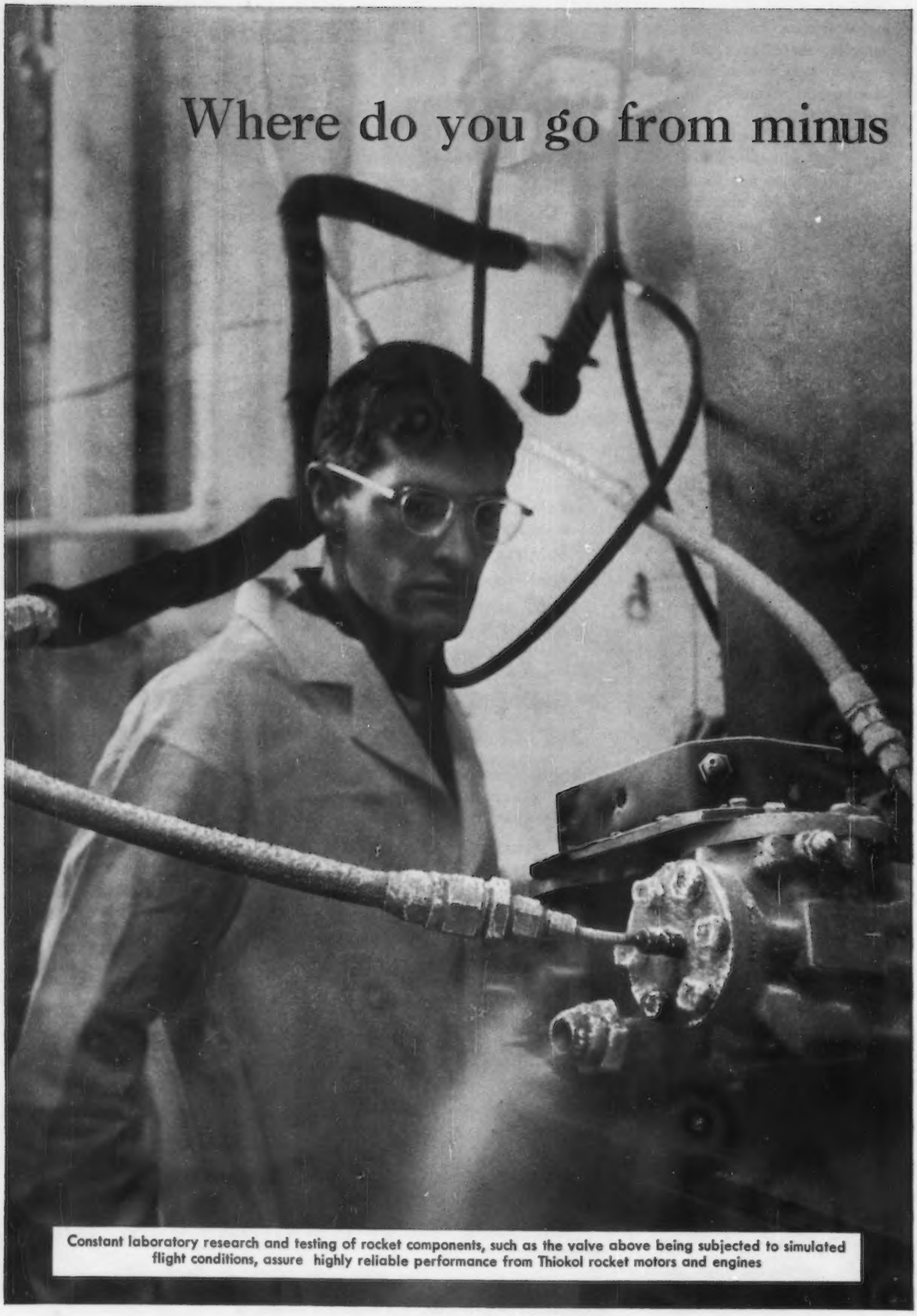
Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼" to 1".

ASK FOR NEW CATALOG 269-A.

BARCO *Serving Industry Since 1908*
MANUFACTURING CO., 565L Hough St., Barrington, Ill.

AIRCRAFT DIVISION

Circle 19 on Inquiry Card



Constant laboratory research and testing of rocket components, such as the valve above being subjected to simulated flight conditions, assure highly reliable performance from Thiokol rocket motors and engines

320°F?

"Malfunction" is the most feared word a rocket scientist can hear. One of its most critical sources is *temperature.* Ranging from hundreds below zero to thousands above, temperature extremes can play havoc with milli-second performance specifications of complex valves and pumping systems.

In picture left, liquid nitrogen flowing through a turbo pump valve of a type used on the powerplant for the Air Force's X-15 drops the temperature within the valve to minus 320°F. This is slightly cooler than in actual operation, when the valve will pump highly combustible liquid oxygen (minus 297°F) and ammonia.

Laboratory tests are an essential part of the continuing research program in new materials, new design and new fuels, carried on by THIOKOL's rocket builders. In close support are the scientists of THIOKOL's Chemical Division, who continually seek new properties for their liquid polymers to meet increasing performance demands.

It is through such scientific team effort that THIOKOL has been able to design and build liquid and solid rocket propulsion systems having a remarkable record for flawless functioning.

To become a THIOKOL scientist is to enter today's most fascinating industrial arena. Challenging assignments exist for research chemists in:

Propellant Analysis; Propellant Formulation; Organic and Inorganic Polymers; Fluorine and Metal Hydrides Synthesis; High Vacuum Techniques; Fast Reaction Kinetics; Shock Wave Phenomena; Combustion Processes.

For engineers, there are scores of exciting career opportunities in the areas of servo system and electro mechanical design, in instrumentation and many other phases of advanced propulsion research.

THIOKOL plants are located in areas that are good places to live—Bristol, Pennsylvania; Elkton, Maryland; Huntsville, Alabama; Marshall, Texas; Denville, New Jersey; Trenton, New Jersey; Brigham City, Utah; Moss Point, Miss. For further information contact: Personnel Director at any plant address above.

Thiokol®

is Research to the Core

THIOKOL CHEMICAL CORPORATION

Bristol, Pennsylvania

®Registered trademark of the Thiokol Chemical Corp. for its rocket propellants, liquid polymers, plasticizers and other chemical products.

Circle 20 on Inquiry Card

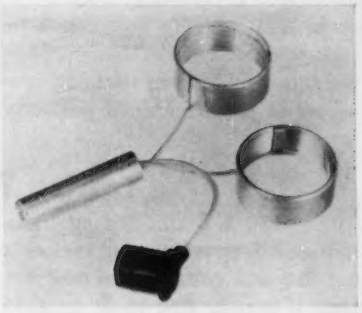
New Parts and Components

conditions. Pressure sensitive diaphragm of the microphone is protected from radiant and conductive heat by a water-cooled flame shield. It is statically calibrated and can be used in remote control operations up to 1200 ft or higher. This transducer can be disassembled for cleaning the flame shield. **Photocon Research Products**

Circle 66 on postcard for more data

Anti-Vibration Filter

New 4000-V filter is designed to keep caps from shaking loose due to vibration, and features



anti-corrosion treatment. For use in military-type systems, filter has self-locking anti-corona cap. All parts are formed or machined at a tolerance of 001.; screwon connectors are used. **Filtron Inc.**

Circle 67 on postcard for more data

Spin Stabilization

A hot gas generator spin stabilization system has been developed for Polaris. Solid propellant gas generator system weighs less than 3 lb. It consists of a solid propellant gas generator, two supersonic thrust nozzles, and appropriate tubing for installation within a given envelope.

The gas generator incorporates an electric pyrotechnic ignition, a time delay and a composite base propellant in a single cartridge.

Flame temperature is 3000 F to 4000 F, providing high specific impulse. **AiResearch Manufacturing Div. The Garrett Corp.**

Circle 68 on postcard for more data

Surface Thermometers

Moisture-resistant self-contained surface thermometers are designed to operate at temperatures from —100° to 500°F—and intermittently from —300° to 575°F. They consist of a 100-ohm (at 70°F) CP Nickel element completely encapsulated in silicone rubber and stainless steel. The stainless steel is only .002 in. thick to provide maximum flexibility. **Arthur C. Ruge Associates**

Circle 69 on postcard for more data

Hydrant Fueling System

Air transportable hydrant fueling system will accommodate 50,000 gal. of fuel. Storage system includes five 10,000 gal. collapsible pillow tanks. System can fuel Air Force jet aircraft with requirements varying from 150 gal. per minute to 600 gal. per min. It also can provide re-circulation, filtration and water removal for the initial supplying of fuel without having to waste or dump any fuel prior to fueling the first aircraft. Pumping and delivery equipment was supplied by Bowser Inc. **Goodyear Tire & Rubber Co.**

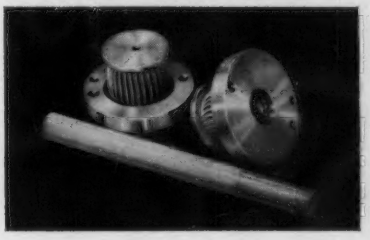
Circle 70 on postcard for more data

Filter & Valve

Small, precision filter with relief valve weighs 1.18 oz; it is rated at 2 microns, and at 15 microns, and at 15 microns absolute.

Filter is designed to operate at 0.3 gpm under normal conditions, and at 0.8 gpm under intermittent surge. It has a temperature range of —65°F to 275°F. Relief valve cracking pressure is 150 ± 15 psi. Materials used are all stainless steel. Filter may be used for hydraulic fluids, corrosives, and gases. **Aircraft Porous Media**

Circle 71 on postcard for more data



New Electronic Products

Magnetic Memory Disk

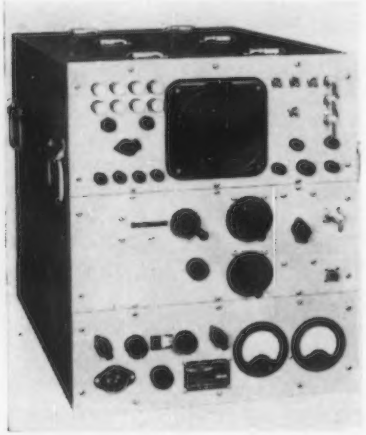
Major development in magnetic data storage is the Bernoulli-Disk, self-adjusting device that can be used in almost any system where a magnetic drum is conventionally employed. Shock resistant device consists of a paper thin disk of mylar magnetic material rotated close to a smooth stabilizing plate. **Laboratory for Electronics Inc.**

Circle 72 on postcard for more data

Microwave Pulse Power

PCS-1 Pulse Power Calibrator measures instantaneous power in pulsed radio frequency energy.

A measurement is established at the time of each use. Ease of operation is assured by direct reading of power measurements, the notch-and-reference line display, which eliminates parallax error, and by automatic centering of pulses on the display.



Basically, the PCS-1 unit measures peak pulse power by comparing the signal amplitude to that of an internally generated, precisely measured, one milliwatt RF signal. **General Communication Co.**

Circle 73 on postcard for more data

Magnetic Limit Switch

A new magnetic limit switch has no moving parts, acts on proximity of its two sensing elements, rather than on actual physical contact.

Known as the Amplet magnet limit switch, the device is intended for automation applications requiring precise control of the relative motion between two parts of a machine. Typical applications include limiting cuts or traverse on such machine tools as shapers, planers and drill presses; stopping conveyors at pre-determined positions; continuous sequencing. **Consolidated Controls Corp.**

Circle 74 on postcard for more data

Testing Transformer

150 KV rms testing transformer is for combination dielectric test set and corona level test set. Unit is corona free to at least 75 KV rms. High voltage oil-filled bushing is corona free to 150 KV rms. Capacity of testing transformer is 10 KVA (also available in large capacities).

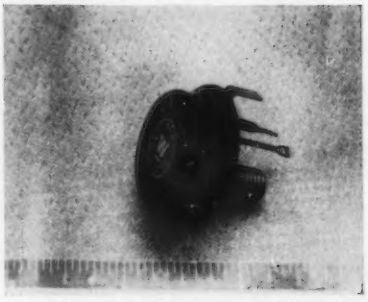
Size of this 10 KVA transformer is 30 in. x 26 in. x 83 in. high including the high voltage bushing. Weight is 90 lb. **Peschel Electronics Inc.**

Circle 75 on postcard for more data

Silicon Triode

A new silicon triode has peak-inverse-voltage ratings up to 400 v.

In the conducting direction (with no input signal to the base terminal) the device will block up to the full rated voltage. When a base signal of 2 to 5 volts is applied, the triode will switch from a blocking to a conducting condition, characterized by a low forward drop similar to that of a conventional silicon triode. The base signal draws a current of 25 to 150 milliamps. **Westinghouse Electric Corp.**



Circle 76 on postcard for more data

Decimal Digitizer

Digitizer provides straight decimal contact output. It is a non-ambiguous electro-mechanical shaft position encoder of the absolute positional multi-speed type. It has 10, 40, 100, 400, and 1,000 counts per rotation. **Coleman Electronics**

Circle 77 on postcard for more data

High-Vacuum Pumps

New series 150 electronic high-vacuum pumps have capacity of 5 to 10 liters per sec.; are suited for general laboratory use, vacuum-tube processing, and thin-film work.

Pumps with magnet weigh 13 lb, are 6¼ x 7¾ x 5 inches. **Ultek Corp.**

Circle 78 on postcard for more data

Phase Sequence Relays

Relay offers automatic monitoring of three phase power. It senses the phase sequence and operates to close a contact when applied phase sequence is A-B-C. Contact remains non operative with the phase sequence of A-C-B. **Master Specialties Co.**

Circle 79 on postcard for more data

Pressure Transducer

Model 2-38, 10-oz, 5 in. 3 pressure transducer is for operation over ambient-temperature range of —40°F to 275°F. Transducer has pressure ranges of 0-150 to 0-2500 psig with resistances of 1K, 2K, 5K and 10K ±5 per cent.

Continuous power ratings are of 1 w at 68°F and 0.75 w at 165°F. Transducers generally conform to environmental requirements specified in MIL-E-5272B. **Edcliff Instruments**

Circle 80 on postcard for more data

NEW

ULTRASONIC THICKNESS GAGE

Now you can measure wall thickness accurately with Sperry's new direct reading ultrasonic thickness gage. Battery-operated, it is small and light enough (10 lbs.) to be carried anywhere — to inspect missile nose cones, other rocket components.

Using the pulse echo method, this new Sperry thickness gage works even where surfaces are not parallel, such as taper forgings. Easy-to-read meter is directly calibrated in inches, and alarm lamps are provided for go-no-go operation.

Send to Sperry for a free bulletin giving more detailed information on the new ultrasonic thickness gage.

There is a full line of ultrasonic inspection instruments available from Sperry, for fourteen years leading designers and engineers of ultrasonic testing equipment. Call a Sperry engineer to help solve your ultrasonic testing problems.

Write for descriptive literature.

Sperry Products Company

a division of Howe Sound Company

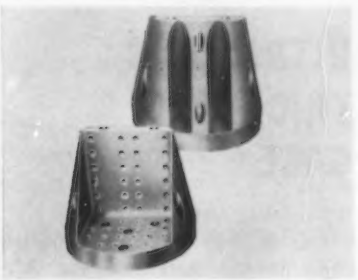
Danbury, Connecticut

New for Production

Rigid Test Fixture

Environmental test fixture may be used interchangeably for vibration shock and acceleration tests to meet requirements of a rigid, resonant-free mounting.

T-type fixture of cast magnesium can test specimens in three mutually perpendicular axes, simultaneously. Similar fixtures have been developed of beryllium for



more demanding test programs. **Avco Research and Advanced Development Div.**

Circle 81 on postcard for more data

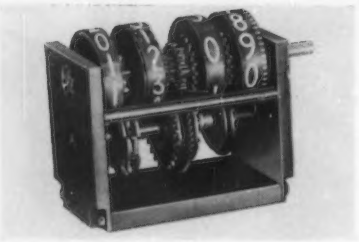
Ratchet Wrench

Lightweight ratchet wrench speeds fitting assembly, close quarter work; is designed especially for tube, hose, and pipe fittings. Jaws are forged chrome-vanadium steel. **The Imperial Brass Mfg. Co.**

Circle 82 on postcard for more data

Clock Type Counter

Counter-style elapsed-time clocks present four quarter-inch-high significant figures at a time. It covers a full day in minutes and hours.



Characters are white on black drums. This aims at making time information more readable than on wristwatch style-time indicators. Smaller and lighter time indicators can thus be made. **Bowmar Instrument Corp.**

Circle 83 on postcard for more data

Grinds Small Holes

Operating at spindle speeds above 300,000 rpm, this air-driven cutting and grinding instrument speeds production of small holes, grooves, slots and die cavities.

The "Airotor," actually an industrial adaptation of the Borden Airotor used in dentistry, grinds holes as small as .025 in. to tolerances of plus or minus .0001 in. It will efficiently machine very hard materials with diamond and carbide tools. **The Ashcombe Co.**

Circle 84 on postcard for more data

Plasma Flame Spraying

Plasma flame spray gun is now available. Operating on inert gases with push button control, it produces flame temperatures to 30,000°F.

Biggest present application is hard-facing for wear resistance. It has sprayed on coatings of tungsten and most inorganic materials that can be melted without decomposition. **Metallizing Engineering Co.**

Circle 85 on postcard for more data

Small Test Unit

This plug-in test unit for small aircraft and missile components simulates altitudes to 200,000 ft. temperatures from —100°F to 350°F. It provides a 14-inch cube of test space in only four square ft. of floor space. **Tenney Engineering Inc.**

Circle 86 on postcard for more data

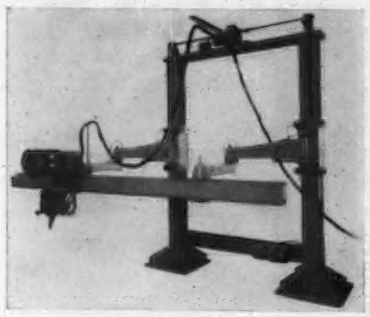
Freon-Sonic Cleaning

New cleaning system combines advantages of sonic energy with use of Freon as solvent. It has been developed particularly for cleaning beryllium parts and ultra precise electronic components. System is housed in a stainless steel cabinet in three different sizes. **Bendix Aviation Corp., Pioneer-Central Div.**

Circle 87 on postcard for more data

Welding Fixture

New line of automatic welding fixtures employs the Pantograph principle to position the welding head. The welding area which can be used with the Pantographs is greater than any other present designed fixture. Single Arm L and B

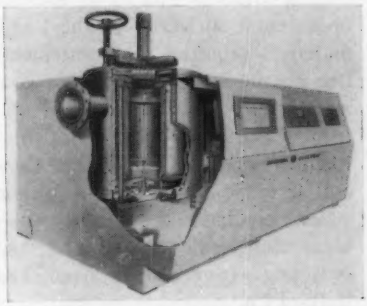


Pantograph can be set up for inside welding. **L and B Welding Equipment Inc.**

Circle 88 on postcard for more data

Vacuum Furnace

Refractory-free, high-temperature vacuum furnace operates at temperatures to 4200F. It processes parts or material up to 10 inches in diameter by 10 inches in height, 50 lb in weight.



Double-wall furnace casing is stainless steel. Tungsten and molybdenum radiation shields surround the load, provide thermal insulation. **General Electric Co.**

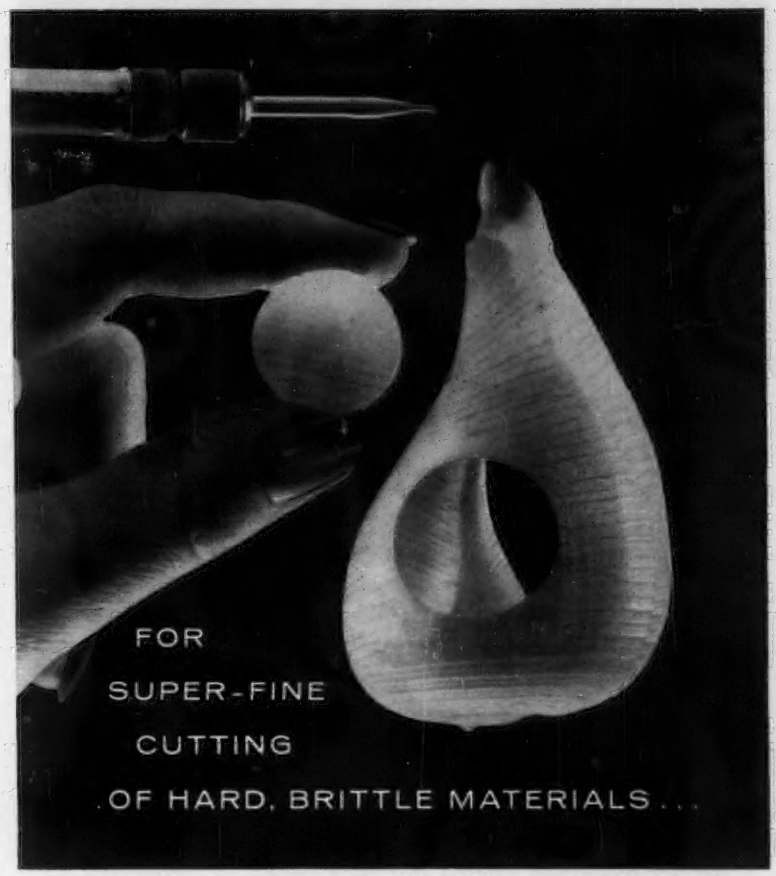
Circle 89 on postcard for more data

Inspecting Small Parts

Index table provides the inspector, machinist and engineer with versatile means of inspecting, machining, measuring or laying out small parts.

Designed for accuracy in a

continued on next page



THE S.S.White Industrial Airbrasive® Unit

We cut a section from this fragile sea shell just to show that *in a matter of seconds* almost any hard, brittle material can be cut or abraded with the S.S. White Industrial Airbrasive Unit.

Cool, shockless, super-precise, the unit uses a controlled stream of fine abrasive, gas-propelled through a small nozzle. It is so flexible in operation that the same simple tool can frost a large area or can make a cut as fine as .008" . . . on a production basis!

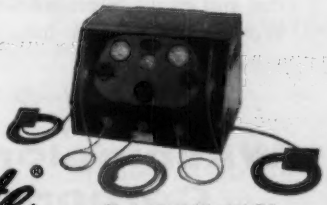
Almost every day new uses are being discovered for the Airbrasive Unit, in the lab or on the production line . . . shaping . . . deburring . . . wire-stripping . . . drilling . . . engraving . . . frosting . . . materials testing . . . cleaning off surface coatings.

All types of hard brittle materials . . . glass, germanium and other fragile crystals, ceramics, minerals, oxides, metal, certain plastics.

Send us your most difficult samples and we will test them for you.

1089

SEND FOR BULLETIN 5705A ...complete information

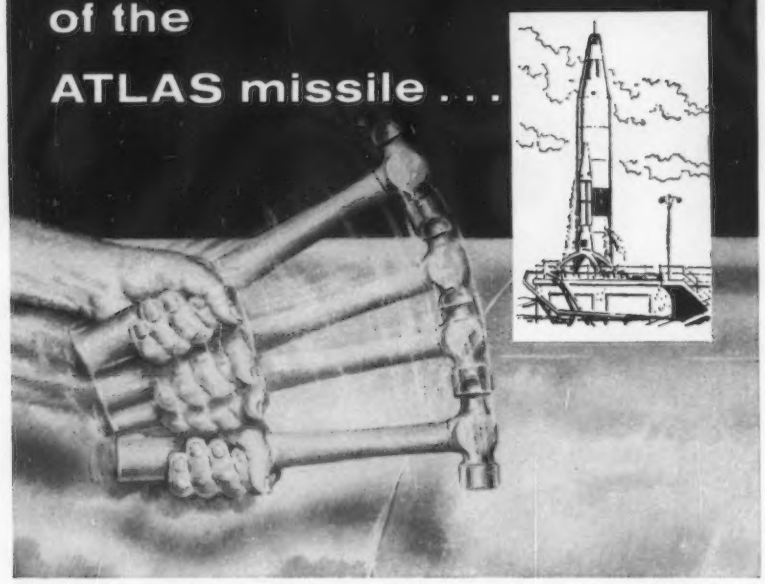


S.S.White®

New dual Model DI

S. S. WHITE INDUSTRIAL DIVISION • Dept. 18-A • 10 East 40th Street, New York 16, N. Y.

How an ordinary hammer proved the case of the ATLAS missile . . .



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered*, for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

This stainless steel skin material, supplied by Washington Steel, required extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

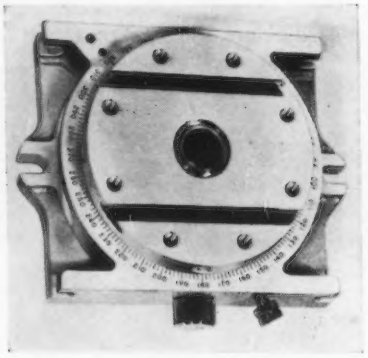
Stainless Steel—the Space Age Metal

Washington Steel Corporation
11-H Woodland Avenue
Washington, Pa.

Circle 23 on Inquiry Card

New for Production

small space, table provides 360 positive locking positions. This elimi-



nates need for careful visual settings usual in devices of this small size. Position can be repeated within 2 minutes of arc. **Calectron Inc.**

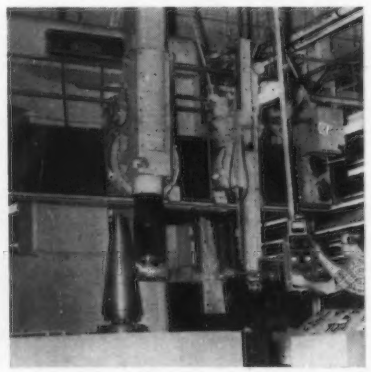
Circle 117 on postcard for more data

Grinds Contours

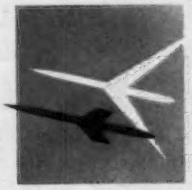
Precision contour cut grinder was developed to grind curved contours—on either internal or external surfaces—in the tough materials required for components like missile cones and exhaust nozzles.

The new Bullard is automatically operated by a special General Electric tracer-control system which regulates three motions—horizontal feed, vertical feed, and swiveling—from a single head. **The Bullard Co.**

Circle 118 on postcard for more data



Worth Asking For



Electronic Buyers' Guide

312 page 1960 Guide to Electronic Buying includes over 40,000 items, is offered to industrial buyers and engineers.

Radio Shack Corp.

Circle 90 on postcard for more data

Pneumatic Vacuum Catalog

Catalog includes data on line of tube fittings.

Lenz Co.

Circle 91 on postcard for more data

Electronic Components

Brochure entitled "The Story Behind Corning Electronic Components."

Corning Glass Works

Circle 92 on postcard for more data

Glass Fabrics

Illustrated brochure shows facilities, techniques in weaving, finishing and impregnating of glass fabrics.

Coast Mfg. & Supply

Circle 93 on postcard for more data

P. E. C.

Basic data on packaged electronic circuits.

Centralab
Div. of Globe-Union Inc.

Circle 94 on postcard for more data

Speed Reducers

Pocket-size 65-pg. catalog covers "Hi-Line" Series speed reducers.

The Ohio Gear Co.

Circle 95 on postcard for more data

Fasteners

15-pg. brochure on one-piece self-locking fasteners.

Western Sky Industries

Circle 96 on postcard for more data

CT-58

GED-3987, 24 page brochure, introduces the CT58 turboshaft engine for commercial helicopter service.

General Electric Co.

Circle 97 on postcard for more data

Honeycomb

TSB-104 "Hardness Condition of Hexcel Aluminum Honeycomb" covers metallurgical condition of the aluminum alloys in expanded honeycomb products.

Hexcel Products Inc.

Circle 98 on postcard for more data

Control Systems

An eight page bulletin on basic design of control systems using linear differential transformers as A. C. transducers with A. C. or D. C. outputs.

Minatron Corp.

Circle 99 on postcard for more data

Electromagnetic Clutches

20-page bulletin provides design, specification and application material on electromagnetic clutches.

I-T-E Circuit Breaker Co.

Circle 100 on postcard for more data

Electronics Research

Booklet describes scope of firm primarily devoted to r & d in missile/space electronics, advanced systems analysis.

Space Electronics Corp.

Circle 101 on postcard for more data

USI Facilities

Complete description of work by firm's divisions.

U. S. Industries

Circle 102 on postcard for more data

Gaskets

Design manual includes application and installation engineering data for all types of Metal O-Ring gaskets.

The Advanced Products Co.

Circle 103 on postcard for more data

Spectrum Analyzers

Complete line of automatic spectrum analyzers described.

Panoramic Radio Products

Circle 104 on postcard for more data

Electronic Time Delay Relays

Catalog contains technical data on line of time delay relays with no-moving-parts transistor timing module.

Tempo Instrument Inc.

Circle 105 on postcard for more data

Metal Surface Processing

40-page catalog on machinery and machinery systems for metal surface processing.

Ransohoff Co.

Circle 106 on postcard for more data

Meters

20-page meter line catalog.

Helipot Div. Beckman Inst. Inc.

Circle 107 on postcard for more data

Photoconductors—Projectors

Compilation of declassified data on lead sulfide photoconductive detectors. Also, bulletin on contour projector optical gaging.

Eastman Kodak Co.

Circle 108 on postcard for more data

Threaded Fasteners

Chart-fold Baedeker to today's aerospace precision fasteners.

Aircraft-Missile Div.
Standard Pressed Steel Co.

Circle 109 on postcard for more data

Breadboarding System

Brochure on servo "breadboarding" system for computer, aircraft and missile fields.

Gap Instrument Corp.

Circle 110 on postcard for more data

Measuring & Control

Engineering services and products for automatic measurements and control of processes.

Chicago Div.
American Bosch Arma Corp.

Circle 111 on postcard for more data

Gamma Radiography

24-page brochure, "Gamma Radiography" includes applications, definitions.

Nuclear Systems Div.
The Budd Co.

Circle 112 on postcard for more data

5000 Psi Axial Piston

Complete details on 5000 psi axial piston pump, Model A-12900 Series.

Aero Hydraulics Div.
Vickers Inc.

Circle 113 on postcard for more data

Air Control Valves

"Valve finder" contains capacity coefficients for line of directional air control valves.

Hannifin Co.

Circle 114 on postcard for more data

Numeric Kellers

Circular describes P & W tracer controlled millers.

Pratt & Whitney Co.

Circle 115 on postcard for more data

Valves & Fittings

Types of standard valves and fittings for 30,000 psi and 60,000 psi service in pure physics investigation, geophysics and reactor research.

High Pressure Equipment Co.

Circle 116 on postcard for more data

PROFILE STUDY DESCRIBES AIRCRAFT - MISSILE ENGINEERS

The 3,030 questionnaires which Aircraft & Missiles sent of a scientific sample of its readership resulted in the first complete report on the men propelling the fastest-growing industry in the U. S.

Contents from the 1,495 returns were converted to IBM punch cards. This allowed a complete breakdown by average numbers responding in a certain way.

Married: 92.7%.
Single: 7.3%.
Average children: 2.
Live in house: 88.2%.
Live in apartment: 11%.
Own residence: 81.8%.
Rent residence: 18.1%.

Market value of home: average was $21,759. Price range went from less than $13,000 (6%) to over $50,000 (1.8%).

Music preferred: classical, 53.9%; popular, 52.9%; jazz, 15.3%; opera, 7.6%.

Length of paid vacation: one week 0.7%; two weeks, 70.1%; three weeks, 25.3%; four or more weeks, 3.9%.

Carrying own private life insurance: 91.8%.

Have company-paid life insurance: 96.8%.

Carrying own private pension plans: 24%.

Have company-contributed pension plan: 93.3%.

Served in the Armed Forces: 62.1%.

How many smoke: 57.4%.

What they smoke: cigarettes, 72.9%; pipes 32.6%; cigars 27.4%.

The job and age breakdown of respondents was as follows:

PHASE OF THE INDUSTRY

	%
Airframes	38.0
Checkout Equipment	9.9
Ground Handling Equipment	14.9
Ground Support Equipment	24.3
Guidance Equipment	23.8
Propulsion Systems & Aux. Power Units	37.2
Test Equipment	20.9
Tracking & Telemetering Equipment	10.2

Adds to more than 100% because of multiple answers.

FUNCTION

	%
Top Management	15.5
Design	49.3
Development	46.6
Production	24.7
Procurement	3.1
Other	1.5

AGE GROUP

	%
Under 25	2.3
25 - 29	13.0
30 - 34	23.4
35 - 39	26.3
40 - 44	18.0
45 - 49	8.6
50 - 54	5.5
55 and over	2.9

Following tabulations cover the main sections of the survey.

INFORMATION SOURCES

	%
Company Training Programs	39.6
Engineering Associations	48.1
Engineering Conventions	33.0
Trade Shows	37.1
Conversation With Others	71.1
Trade Magazines	95.7
College Courses	23.4
Technical Books	2.4
None	.3
Other	.6
Don't Know	.1

YEARS IN THE INDUSTRY

	%
Under 5 years	21.3
5 - 10 years	37.5
11 - 15 years	13.1
16 - 20 years	18.1
21 - 25 years	6.2
26 - 30 years	2.1
31 - 35 years	1.0
Over 35 years	.7

NUMBER OF PLANTS OR COMPANIES

	%
One	42.3
Two	24.9
Three	14.3
Four	6.9
Five	4.8
Six	2.8
Seven	1.5
Eight	1.0
Nine or more	1.4
Other	.1

CAREER GOAL

	%
Top Management	25.2
Chief Engineer, Senior Engineer, Head Engineer	10.3
Middle Mgmt., Department Head	28.2
Section or Group Leader	1.8
Project Engineer	1.6
Staff Engineer	.9
Consulting Engineer	2.3
Sales & Marketing Engineer, Administrative Engineer	.2
Engineer (all other types)	8.2
Top Salary, Financial Success	.6
Do a good job, contribute to field	6.7
University or College Position	1.0
Have Attained Goal	1.7

% SALARY INCREASE REQUIRED TO MAKE A LOCAL JOB CHANGE

GEOGRAPHIC AREA	MEAN
New England	20.1
Middle Atlantic	18.0
E. N. Central	18.9
W. N. Central	19.0
South Atlantic	19.3
E. S. Central	15.4
W. S. Central	18.3
Mountain	17.3
Pacific	18.1

% SALARY INCREASE REQUIRED TO MAKE A JOB CHANGE TO ANOTHER PART OF THE U. S.

GEOGRAPHIC AREA	MEAN
New England	31.2
Middle Atlantic	27.3
E. N. Central	28.5
W. N. Central	28.2
South Atlantic	27.2
E. S. Central	27.9
W. S. Central	28.4
Mountain	25.6
Pacific	30.5

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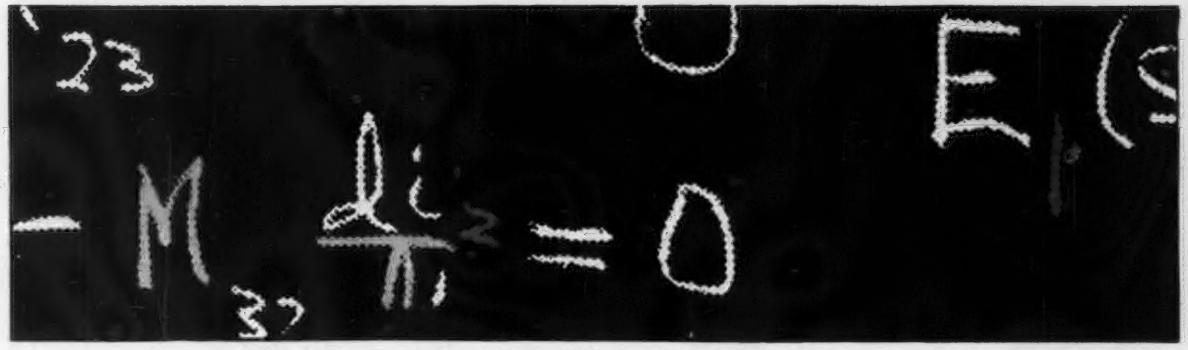
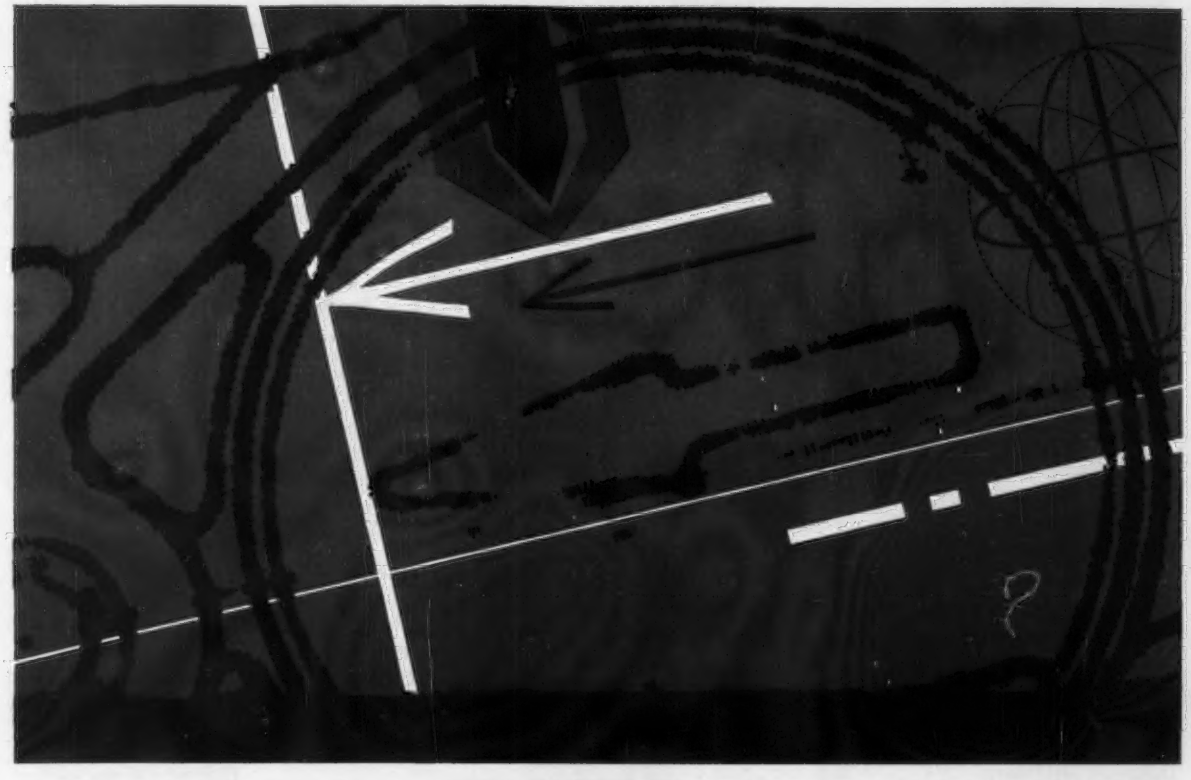


General Motors pledges

AC QUESTMANSHIP



AC Seeks and Solves the Significant—AC Design and Development is moving far ahead in new technology—the result of GM's commitment to make ever larger contributions to the defense establishment. AC plans to resolve problems even more advanced than AChiever inertial guidance for Titan / This is AC QUESTMANSHIP. It's a scientific quest for the development of significant new components and systems . . . to advance AC's many projects in guidance, navigation, control and detection / Dr. James H. Bell, AC's Director of Navigation and Guidance, sees this as a "creative challenge". His group takes new concepts and designs them into producible hardware having performance, reliability and long life. He strongly supports the fact that an AC future offers scientists and engineers "a great opportunity to progress with a successful and aggressive organization" / If you have a B.S., M.S., or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience, you may qualify for our specially selected staff. If you are a "Seeker and Solver", write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG *The Electronics Division of General Motors*

Profile Study... Continued

APPROXIMATE MARKET VALUE OF HOME

	%
Less than $12,999	6.0
$13,000 - $15,999	17.8
$16,000 - $18,999	21.2
$19,000 - $21,999	16.7
$22,000 - $24,999	13.2
$25,000 - $27,999	8.4
$28,000 - $30,999	5.9
$31,000 - $34,999	4.4
$35,000 - $39,999	2.6
$40,000 - $49,999	2.0
$50,000 and over	1.8

HIGHEST LEVEL OF FORMAL EDUCATION

	%
Some High School	.6
High School Diploma	3.1
Technical School	7.3
Some College	22.0
College Degree	37.4
Post-graduate Study	29.5
Other	.1

LIFE INSURANCE PROVIDED BY EMPLOYER

	%
$ 1,000 - $ 5,000	10.5
$ 6,000 - $10,000	26.3
$11,000 - $15,000	18.0
$16,000 - $20,000	17.9
$21,000 - $25,000	10.4
$26,000 - $30,000	6.1
$31,000 - $35,000	1.9
$36,000 - $40,000	2.3
$41,000 - $45,000	.2
$46,000 - $50,000	.8
$51,000 and over	.7
Depends on Salary	4.6
Don't Know	.3

ACTIVITIES

Civic Organizations	22.4
Social Welfare Groups	21.4
Veteran's Organizations	7.0
Church Groups	48.5
Fraternal & Service Organization	34.6
Country Club	7.7
Professional Business Association	47.6
Other Sports Clubs	21.7
Other Organizations	9.7

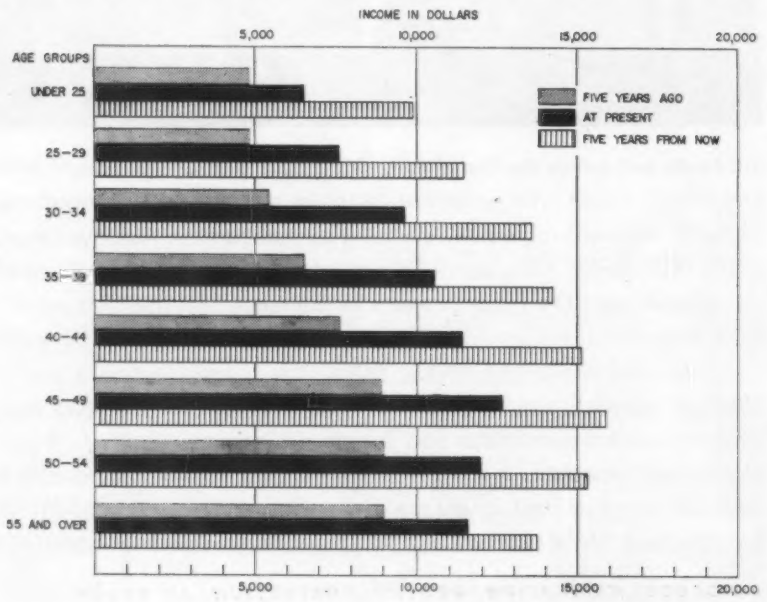
Adds to more than 100% because of multiple answers.

HOBBIES

	%		%
Art	1.0	Sport Cars	2.8
Study (courses)	1.2	Antique Car Repairing	4.6
Theatre (movies)	.7	Printing, Hand, Art	4.2
Minerology	.9	Climbing	.2
Spectator Sports	.9	Camping	3.3
Photography	19.4	Religious Church Work	1.2
Gardening, Etc	20.7	Models	6.2
Reading	16.1	Coin Collecting	1.6
Tennis	2.2	Model Railroading	2.8
Golf	17.9	Family	3.2
Swimming	6.9	Skiing	3.2
Fishing	21.1	Water Sports, Skiing, Skin Diving	2.1
Bowling	8.0	Marksmanship, Rifle, Pistol	1.6
Music Records	10.1	Archery	.7
Hi-Fi	6.9	Hiking	1.9
Ham Radio	2.8	Baseball, Softball	2.0
Radio & TV	2.2	Cards	3.4
Travel	3.6	Chess	1.3
Sports (not specified)	4.6	Astronomy	.7
Sports (specified)	2.9	Dancing	1.3
Hunting	7.3	Stock Market-Finance	1.2
Flying	3.8	Home Workshop	5.4
Boating	11.4	Pets	1.2
Youth Activities	2.2	Wine, Women & Song	.7
Wood Working	14.9	Gun Collecting	1.3
Repairing & Building	12.7	Fraternal, Civic Organizations	2.7
Stamp Collecting	3.4		
Writing, Technical-Creative	.6		
Electronic Gadgets	3.8		

Does not add to 100% because of multiple answers

MEDIA INCOME AT PRESENT, 5 YEARS AGO AND WHAT IS EXPECTED FIVE YEARS FROM NOW.



Men on the Move

REX WELCH, named manager of sales for Electronic Systems Development Corp., subsidiary of Solar Aircraft Co.

JOHN R. MORTON, appointed production engineering manager of the Whittaker Controls Div. of Telecomputing Corp.

EVAN G. LAPHAM has joined Avco Research and Advanced Development Div. He will take over direction of Reference Standards Laboratories concerned with electrical, radio frequency and physical measurements.

THOMAS L. REGAN, named general superintendent of manufacturing for North American Aviation's Missile Division.

BERT W. MARSHALL, JR., appointed new director of the west coast office, Crosley Div., Avco Corp. T. M. O'DONNELL, named director of marketing for missiles at the division's headquarters in Cincinnati.

W. T. HARMON, appointed manager-Product Support, Production Engine Dept., General Electric Flight Propulsion Div., Cincinnati. N. R. FRISCHHERTZ, now manager—J79 engineering project, Jet Engine Dept.

PREBEN K. JOHNSTON elected Secretary and Treasurer, Nuclear Electronics Corp.

BARNET R. ADELMAN, elected general manager and member of the board of directors, United Research Corp., conducting research and development work in advanced propellants and rocket engines.

CREGG COUGHLIN, appointed assistant to the president to represent Fairchild Engine and Airplane Corp. in Washington.

MAJ. GEN. DONALD N. YATES, USAF, has been designated Department of Defense representative for Project Mercury support operations.

MALCOLM F. BROWN, JR., named assistant to the vice president of engineering, Resdel Engineering Corp.

RICHARD P. SIMMONS, named manager of quality control by Latrobe Steel Co.

GARRET E. "GARRY" WRIGHT, appointed manager of special computer sales in the new Lockheed Electronics and Avionics Division (LEAD).

IVAR C. PETERSON, appointed assistant to president of Lear Inc. to direct and supervise technical planning.

PETER H. STANTON, elected chairman of the board and chief executive officer of American Avionics, Inc.

DAVID E. SHONERD appointed vice president, engineering, at Rocket Power Inc.

DR. MOSTAFA B. TALAAT has joined Martin's Nuclear Div. to direct all research and development in the field of energy conversion.

JOHN W. DIXON, appointed manager of long range planning at Convair-San Diego.

WILLIAM C. HOWELL, named assistant manager of the Chemical Propulsion Div. of Hercules Powder Company's Explosive Dept.

JOHN B. MOSS has joined Vertol Aircraft Corp. as assistant to the president. FRANK K. MACMAHON, appointed manager of military programs.

RAY P. LAMBECK, appointed Engineering Manager-Major Programs for the Aero Hydraulics Div., Vickers Inc.

W. PAUL SMITH, appointed a vice president of American Bosch Arma Corp.

R. S. (RIK) ANDERSON, appointed manager of the Leach Corp., Special Products Div.

DOUGLAS M. HELLER, appointed assistant group executive in charge of the aircraft and automotive sections of the Bendix Products Div.

HENRY JACOBI, appointed president of the Defense Products Div., The Brunswick-Balke-Collender Co.

RUSSELL W. CHRISTENSON, recently appointed General Manager of Thermoid Div., H. K. Porter Co., has been elected a Vice President of Porter.

WILLIAM BLINOFF, appointed midwest regional sales manager for Sperry Semiconductor Div., Sperry Rand Corp.

Ivar C. Peterson
Lear

John W. Dixon
Convair-San Diego

Ray P. Lambeck
Vickers

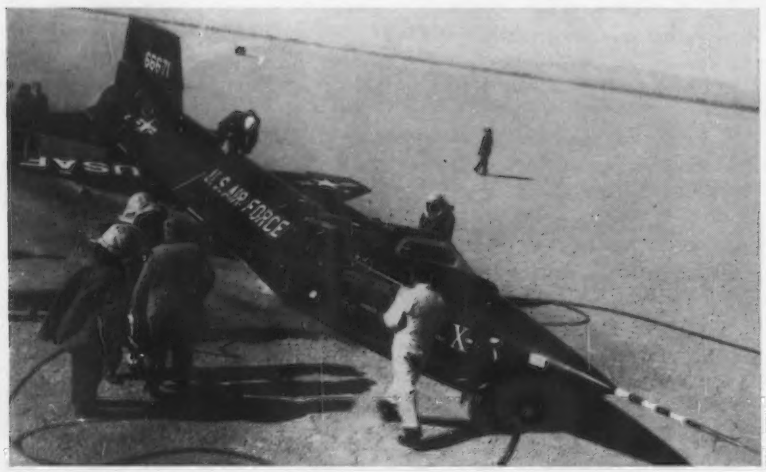
Douglas M. Heller
Bendix Products Div.

William Blinoff
Sperry

Russell W. Christenson
H. K. Porter

Industry Notes

X-15 ACCIDENT, DAMAGE, REPAIR



OVERWEIGHT CONDITION on landing is called the major cause of X-15 fuselage damage. Landing followed in-flight explosion in No. 1 chamber of No. 2 rocket engine. North American test pilot Scott Crossfield guided ship down after automatic engine shutdown.

FUSELAGE SECTIONS tore at station 226 on landing. About 100 of the 125 countersunk screws sheared or pulled through skin.

All igniters lit normally before the main propellants entered the combustion chambers in the X-15 accident of Nov. 5. But before normal combustion took place in the upper chamber of the lower XLD-11 engine, the igniter in this location went out. Reason for this is still unknown. The accumulation of propellant in the combustion chamber exploded, probably after streaming back and contacting the exhaust flames from the other chambers. Automatic engine shutdown took place. No attempt was made to restart. Pilot Crossfield elected to "ride" the aircraft down to a dry lake bed.

Explosion damage on the rocket motor was confined mainly to the defective combustion chamber. No major structural damage occurred in the engine bay. There was some burn damage to local electrical wiring, and the aluminum brackets supporting the high pressure spheres in the bay were damaged. Repairs carried out later were of the "sheet metal" variety.

Landing Damage

Landing weight was in excess of that experienced during other flights. Reason is that jettisoning propellants does not drain the tanks as completely as "burning" them out.

Initial contact was made on the rear skids. When the conventional nose landing gear hit the ground the monocoque fuselage failed at the manufacturing break located at station 226. This joint is just forward of the front torus bulkhead of the liquid oxygen tank at the rear of the forward fuselage section.

The structure is joined at station 226 by a series of 3/16-in. diam A286 stainless steel countersunk screws. Approximately 100 of the 125 screws sheared or pulled through the fuselage skin. The fuselage sections parted causing a distinct sag at this point, low enough for the lower skin to scoop a large amount of dirt up into the bay.

The Repairs

Despite the impressive looking fuselage break and sag, structural damage was confined to the join area. Local buckling occurred on the skins near the join, the forward face of the liquid oxygen tank torus bulkhead was wrinkled in several places. There were no weld failures.

The liquid oxygen tank was pressurized to 95 psig for proof testing, before and after repairs to the wrinkled areas. At the proof pressure, several wrinkles came out without further work. The others

were hammered out. Fuselage skins at the break were straightened out then patched wherever the countersunk screws had pulled through. An internal doubler was added to the top and bottom skins at the join area to give double instead of single shear strength.

Within four weeks of the landing, repairs were completed.

B-70 Development

Under the B-70 "stretch-out," Subcontracts of the following firms were cancelled: Lockheed, Boeing, Chance Vought, IBM, Westinghouse, Motorola. North American Aviation, prime, will do the bulk of the present development work.

Electronic Ramparts

The BMEWS (Ballistic Missile Early Warning System) base at Thule, Greenland, will be operating this year. Similar base is being built at Clear, Alaska. A third base is planned. BMEWS radar screens can spot a missile 3,000 miles away.

Spatial Eavesdropping

Radar antenna with 1,000 ft diam, to be built by Cornell University for ARPA in Puerto Rico will be able to receive signals bounced from the moon, study roughness of Venus and Jupiter, and probe the relations between the ionosphere and missiles.

Contracts

The Defense Department authorized the Air Force to increase production of the Mace B. Funds alloted: $100-million.

General Electric received a $101-million contract to further develop advanced nose cones. Major funding covers R & D on a new nose cone for Atlas. Firm's Jet Engine Dept. got $6.5-million for further J93 powerplant development.

Army awarded Western Electric Co. $11,889,500 for improvements in the Nike Hercules system; and awarded $8,617,624 to Aeronutronics Div. of Ford Motor Co. for Shillelagh development.

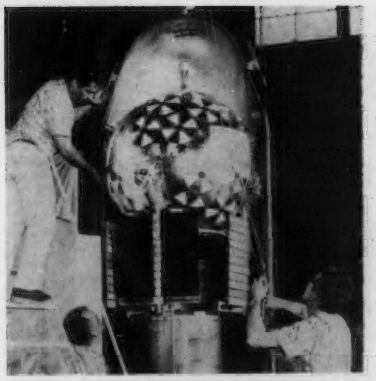
Raytheon Co. accelerates development of a long range ICBM—tracking radar under a $15-million contract from the Rome Air Development Center. Equipment will be used with ARPA's Project Defender.

The Navy awarded Westinghouse Electric $5,250,000 for initial work on submarine-borne launching systems for Polaris.

Radioplane Div., Northrop Corp., was awarded $7,524,407 for RP-76 target drones for the Army.

The Navy awarded Lockheed $19,200,000 for GV-1 transport planes.

The Air Force awarded $6,627,092 to the Government and Industrial Div. of Philco Corp. for engineering on AIRCOM, the Air Force's global communications network.



"BEAUTIFUL PAYLOAD." Atlas Able IV payload was to ride briefly inside two-piece plastic shroud. Moon shot failure Nov. 26 was blamed on shroud's premature release.

Aerospace Log

Nov. 20—Discoverer VIII orbited. It ejects 300 lb re-entry capsule which is not recovered.

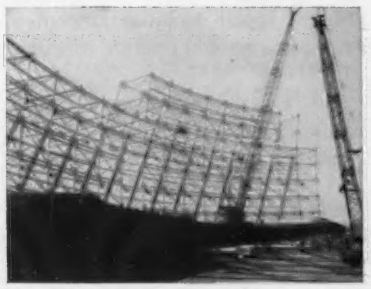
Nov. 26—Atlas Able fails, before third stage firing, in attempt to orbit moon.

Nov. 28—Cmdr. Malcolm Ross, of the Office of Naval Research, and Charles B. Moore, of Arthur D. Little, ride 15 miles high in sealed gondola.

Dec. 4—Little Joe escape capsule carries Sam the rhesus monkey 55 miles high. Sam picked up 200 miles from launch site.

Dec. 12 — Titan explodes few ft off launching pad at Cape Canaveral. It was second explosion ruining attempt at firing live second stage.

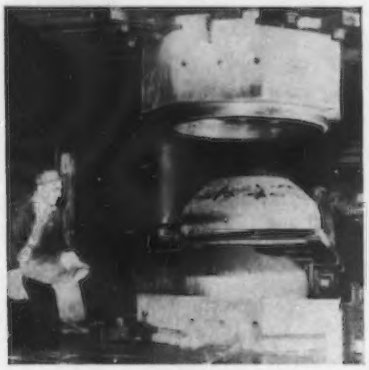
STEEL FRAME being erected for Arctic BMEWS radar antenna. RCA is network's prime contractor.



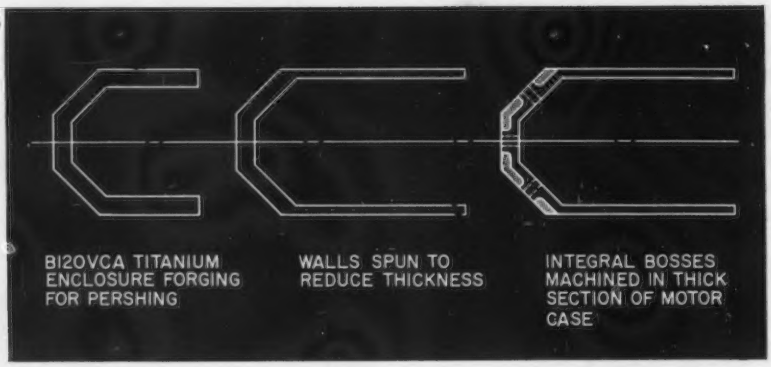
SCATTER ANTENNAS in Air Force's Eglin Gulf Test Range communications network.

ROTATING radio telescope with 600 ft wide reflector is being built near Sugar Grove, W. Va.

Industry Notes



B120VCA TITANIUM motor casing closure for missile is forged on 50,000 ton closed-die press at Wyman Gordon's North Grafton, Mass., plant.


B120VCA TITANIUM ENCLOSURE FORGING FOR PERSHING
WALLS SPUN TO REDUCE THICKNESS
INTEGRAL BOSSES MACHINED IN THICK SECTION OF MOTOR CASE

FORGING is reduced and machined to specifications. Before machining, it weighs 441 lb, has 41.16 in. outside diam.

Materials Outlook

Wyman - Gordon reports it has produced record-sized forgings of the high strength, high temperature **superalloy called "Astroloy."** Guaranteeing minimum properties in forgings up to 40 in. in diam., firm says Astroloy parts will allow operating temperatures of missiles and jet engines to be increased as much as 200 deg.

Resin - bonded quartz sheet, called a combination of reinforced plastics and ceramics, is new ablation-resistant high temp material developed by Cordo Chemical Corp.

The Research Laboratories of The International Nickel Co. recently announced a new "family" of **high strength nickel alloy steels.** The 25 per cent nickel steels are air cooled from the heat treating temperatures.

Linde Co. reports that **tungsten coatings** are protecting solid propellant graphite rocket nozzles both when applied directly to the base material or over tantalum and rhenium undercoatings.

New Facilities

Two launch silos for Minutemen are being built at Patrick Air Force Base by **Dravo Corp.,** under sub-contract from **George A. Fuller Co.**

New Bio - Dynamics Div. of **Republic Electronics Industries Corp.,** Farmingdale, N. Y., is giving primary attention to development of physiological transducers, bio-technical systems and related instrumentation for high altitude flight.

General Electric is building a $14-million space research and development center near Valley Forge, Pa. It will be part of the G-E Missile and Space Vehicle Department. The firm is manufacturing 1/6 oz. metal-ceramic lighthouse triode tubes in a new controlled atmosphere area at its Scranton, Pa., power tube plant.

Aerojet-General has formed a new AETRON Div. combining its architect-engineer and electronic design groups. Purpose: integrate skills in developing facilities for the manufacture test and development of weapons systems and space vehicles.

Rohr Aircraft is expanding stainless steel honeycomb production area from 23,500 sq. ft. to 31,250 sq. ft. Rohr is also constructing permanent electric blanket brazing facilities capable of handling six brazing units simultaneously.

Linde Co. is operating a new liquid hydrogen facility at its Tonawanda, N. Y., labs. It can produce 25,000 liters per month.

New 40,000 sq. ft building at **Boeing-Wichita** houses 15 research and development labs including propulsion, structures, and electronics.

Fourteen-story, $10-million administration building is to be built by 1962 at **Minnesota Mining and Manufacturing's** research center near St. Paul, Minn.

U. S. Signal Research and Development Laboratory at Fort Monmouth, N. J., is beginning operation of eight-ft.-long stainless steel test chamber duplicating the environment 100 miles high. It was built by NRC Equipment Corp.

The Air Force announced plans to build a plant adjacent to **Thiokol's Brigham City, Utah, facility** for production of Minuteman's first stage engine. Air Force plans to build Minuteman assembly and repair facilities at Ogden, Utah. Boeing will operate this unit.

Convair-Astronautics is designing a launch complex at Cape Canaveral, Fla. To be completed next year under Air Force contract, it will include a 166 ft gantry and facilities for storage and handling of high-energy hydrogen.

Polytechnic Research and Development Co., producer of microwave test equipment for advanced communications, is being acquired by **Harris-Intertype Corp.** from the Polytechnic Institute of Brooklyn.

Temco Electronics is building a 20,000 sq. ft. Radiation Systems Laboratory at Garland, Texas, for use in antenna design and development.

General Instrument Corp. has opened an Advanced Development Laboratory in Westbury, L. I., for advanced research and development in military electronics.

Almasol Corp., newly-established subsidiary of Lubrication Engineers, Fort Worth, will develop and market lubricants and solid firm materials for the aircraft industry.

Vanguard Computing Center, Washington, D. C., is now named the **IBM Space Computing Center.** It is now setting up computing programs for Project Mercury.

Production Techniques

New process announced by Schwarzkoph Development Corp. produces **tungsten ingots weighing up to 200 lb.** Blocks of about 8 in. diam. and 8 in. height are formed from tungsten powder in large presses. They are then sintered indirectly in large high temperature furnaces and forged at high temp.

Gear-hobbing machine called the most accurate ever built is being installed at Belock Instrument Corp. It gives precision within 3 sec. of arc—15 millionths of an inch per inch.

New **shell-casting process** developed by Ferro Cast, div. of J. B. Rea Co., Santa Monica, gives time economics in investment casting by replacing the heavy investment-filled steel flask with an inexpensive thin coating surrounding the disposable wax patterns.

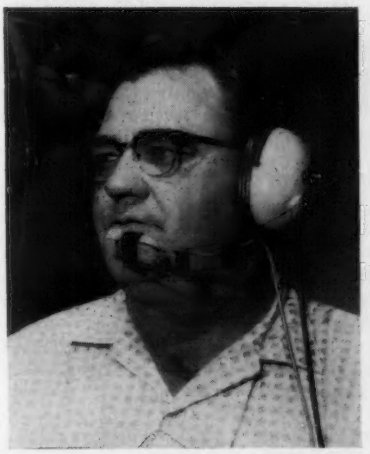
The War on Plant Noise

A systematic anti-noise campaign has operated on an all-plant basis at Lockheed Aircraft Corp., Burbank, Calif., since 1943. Management had many questions to consider in cutting down the clatter normally related to aircraft production. Factors included cost, employee attitudes, and liability, i.e., whether hearing tests and noise control would automatically invite claims against the company.

First step in the campaign was a pilot study in the form of audiometric examinations on employees in certain noisy areas. Noise levels throughout the Burbank plant were surveyed.

Lockheed assigned direct responsibility for the actual noise control and hearing conservation measures in its Medical and Safety Departments, assisted by experts from the firm's Workmen's Compensation carrier.

The Safety Department identified all noisy areas and occupations, earmarking them for corrective measures. From this data, the Medical Department could begin classifying employees for noise exposure.



CHANCE VOUGHT microphone allows voice communications in 150 db of noise. Pre-amplifier is on cord connecting headset and microphone.

At first, audiometric tests were only given to employees and job applicants where noise exceeded 85 decibels. Significantly, this turned out to include about 45 per cent of all personnel. The level for beginning tests was subsequently raised to 95 decibels.

All applicants are now included in initial pre-employment testing, and all new employees are given an otoscopic examination as part of their complete physical when they are hired.

Tests are important. One survey shows that 20 of every 100 newly-hired workers in heavy industry have some hearing loss. Further noise exposure could cause further hearing impairment. Also, a claim may be filed for hearing damage. If employers have no record of the worker's hearing ability when hired, the firm may be liable for the entire accumulated damage.

Using audiograms, which have been administered by registered nurses in the audiometric testing section, Lockheed can place employees on jobs "compatible" with their hearing. An employee fits into one of four categories:

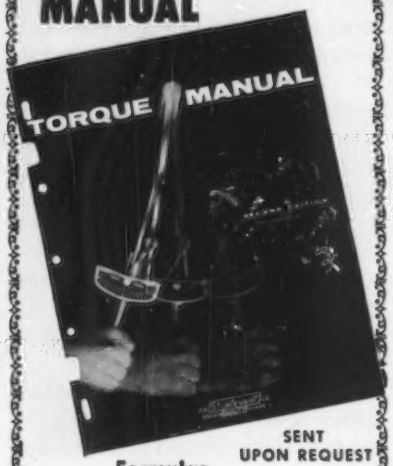
- Able to work in any noisy area.
- Able to work only where noise is less than 95 decibels.
- Able to work in noisy areas but not on jobs where hearing deficiencies would be hazardous.
- Unable to work in noisy areas or on jobs where inability to hear warning signals would be dangerous.

About one-fifth of the work force is reexamined every four months. Employees in the drop-hammer department are tested twice a year. Those working in noisy areas of about 95 decibels are tested once a year.

Ear protection is provided by the safety department. This takes the form of earplugs or earmuffs for areas over 95 dc's.

When possible, noise is controlled at the source: machinery.

"TORQUE WRENCH" MANUAL



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Formulas
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Engineering Data
Screw Torque Data
Adapter Problems
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Economy series; integral plain pilot

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Readers' Orbit

The editors welcome reader comments. Signed letters, submitted on company letterhead, will be published in this column.

Nothing But The Facts

. . . On page 67 of your October issue you show two photographs under the heading, "Sealing the DC-8" . . . you refer to PR-1422 as a sealant developed by Thiokol Chemical Corp. and processed by Products Research Co. This statement is incorrect, as PR-1422 has been developed in its entirety by Products Research Co. and is covered by U. S. Patent No. 2,787,608.

. . . The referenced publicity is harmful to us . . . we are asking you to take the necessary measures to inform your reading public of the true facts immediately.

George Gregory, president
Products Research Co.

The facts are these: PR-1422 is a product of Products Research Co. Thiokol is the supplier of the polysulfide "base" material.

Beryllium . . . Needs Decimal Point

. . . The article on beryllium (Nov., 1959) was excellent . . . The sentence concerning maximum allowable concentration of Be in the air as being 20 micrograms per cubic meter, is open to question. The AEC states . . . "permissible levels for airborne beryllium contamination allow an average daily exposure of 2 micrograms per cubic meter, with no peak exposure greater than 25 micrograms." . . . I look forward to the article on joining.

M. G. Gosselink, Jr.,
manager
Customer Relations
Leemath Inc.

For the want of a decimal point a great deal of accuracy is often lost. Reader Gosselink knows his safety regulations. AEC recommendations clearly call for 2.0 (not 20) micrograms or less per cubic meter.

Navy Researches Polyurethanes

. . . Would you correct the error made in the title of my article. The title as published in your November issue (p. 75) read, "Navy Lab Studies Acrylic Laminates," it should have read "Navy Lab Studies *Polyurethane* Laminates."

Angelo P. Bonanni
Naval Air Material Center

Cold Point Drills

. . . we must register something of a dissent to the material contained in "Machining These HT Alloys" so far as it applied to Cold Point Drills.

We are at a total loss to know where the recommended feed per revolution came from. It is not ours . . . we regard 1500 rpm as a minimum rpm for most applications and insist that these be coupled with feeds of 0.001 to 0.002 ipr.

This can all become very confusing since the recommendations for use of Cold Point Drill are completely contrary to those for any other drill. . . .

Louis H. Doerman,
Mossberg Inc.

Information came from GE Metallurgical Products Dept., who state experimentation was done with some measure of Mossberg cognizance. However, more recent findings tend to supersede this data. Readers may look for "HT Alloys Are Easy To Drill," which will give up to the minute data in November issue.

No Fooling—A Hot Subject

. . . Just finished sloshing through Mr. Ronald A. Cole's article . . . "what makes the TU-104 so hot?" in which he claims that the Vulis Nozzle (pronounced fool-us) can increase thrust by "18 to 22 per cent." This is not only a phenomenal break-through in . . . jet propulsion, but I can visualize many other uses for this "hot" device. One which comes immediately to mind is to melt all the snow . . . Cole has created. I can't reason why this was published by an accredited magazine . . . there is no scientific basis for all that "Vulis Equation" palaver . . . your magazine is trying to make "Vuls" of its readers.

Charles A. Peek, Jr.
Engineer
Pratt & Whitney
Aircraft Corp.

New Books AND Reports

INDUSTRIAL LEADERSHIP. C. A. Weber and J. W. Karnes, Jr. Chilton, 1959, 226 pp. $5.00. This book presents an analysis of leadership as a dynamic factor in our society. Many of the previously-established attribute lists for leadership are outlined and criticized; an updating of needs for leadership is made, together with an evaluation of attributes, in the light of our social and technological changes. Thought-provoking questions are listed at the ends of chapters for the use of groups working on problems of leadership. A thirteen page bibliography is included as an aid for further studies.

TRUE POSITION DIMENSIONING. D. Bibeau and D. Sweet. Bendix-Scintilla, 1959, 28 pp. $3.00 per copy; $2.50 per copy in lots of 10 or more. This four-color, illustrated text presents a step-by-step, easily-understandable explanation of dimensioning and tolerancing principles. Method discussed of expressing tolerances can be applied to any standard system of dimensioning where interchangeability of parts is required. This brief presentation should dispel many dimensioning and tolerancing bugaboos for the designer.

MATERIALS FOR ROCKETS AND MISSILES. R. G. Frank and W. F. Zimmerman. Macmillan, 1959, 124 pp. $4.50. This is a pocket-size, general source-book for engineering properties of metals and ceramic materials. Production methods, constituent elements, and recommended uses for each material are given. Also, new material fabrication processes, including high-temperature brazing, chipless production and unconventional machining techniques are briefly discussed. A five-page bibliography is included.

continued on next page

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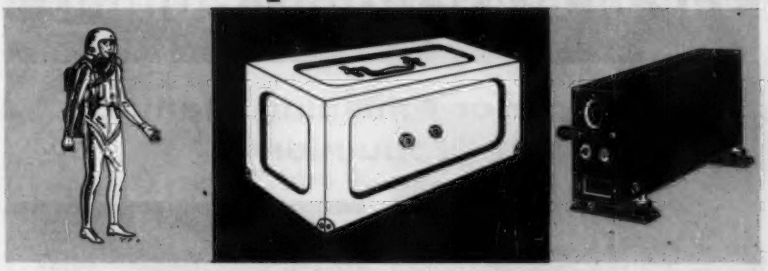

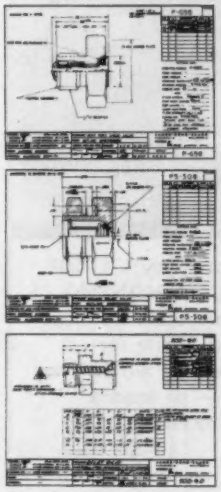

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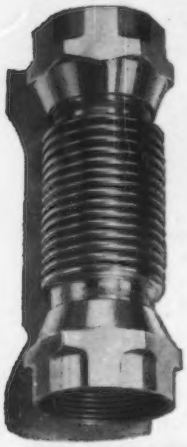

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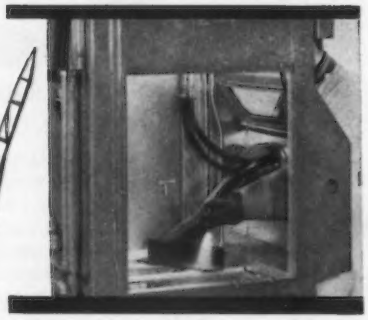

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New Books and Reports

continued from page 67

THE THEORY AND DESIGN OF MAGNETIC AMPLIFIERS. E. H. Frost-Smith. Wiley, 1958, 487 pp. $12.50. First volume in a series on Automation and Control Engineering, it is intended to correlate the theory of all types of magnetic amplifiers, and to present design methods for meeting special requirements. Theoretical aspects, numerical examples, and a number of complete designs are presented. Chapters are devoted to the following topics: the transductor; transient and steady-state operation of idealized transductors; the self-excited transductor; transductors with autoexcitation; transductors with reactive loads; closed loop control systems; transient and frequency response of transductors; high-speed transductors and magnetic amplifiers; balanced magnetic amplifier circuits; low level amplification and multi-stage amplifiers; magnetic modulators; construction and design of magnetic amplifiers; application of magnetic amplifiers.

ASBESTOS: ITS INDUSTRIAL APPLICATION. D. V. Rosato. Reinhold, 1959, 214 pp. $5.75. Intended for those who would like to familiarize themselves with asbestos in general, this handy booklet offers an over-all view of properties, methods of fabrication, and applications. A census of asbestos products is included; chapters are devoted to asbestos-cement products, tile, heat insulation, electrical insulation, friction materials, textiles, plastics, packings and gaskets, filters, and others. A seven-page bibliography is also included.

WELDING HANDBOOK. (Fourth edition, Section Two) A. L. Phillips. American Welding Society, 1958, 550 pp. $9.00. This is the second authoritative reference volume of a

continued on page 71

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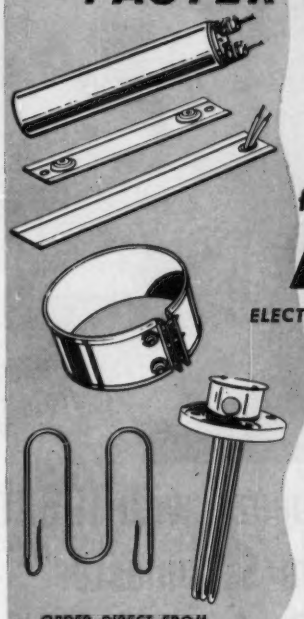

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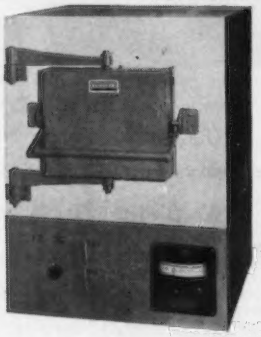

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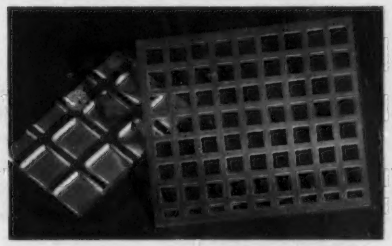

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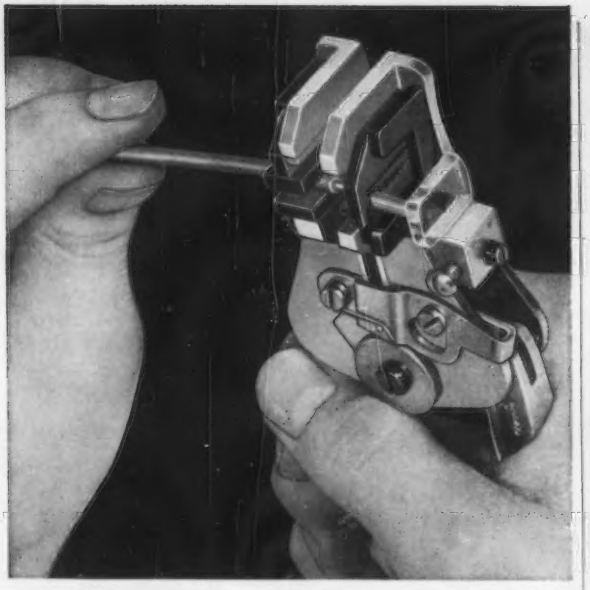

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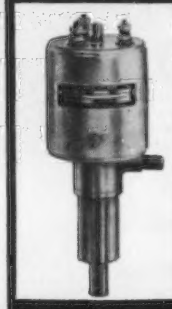

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New Books and Reports

continued from page 68

series representing the cooperative effort of the welding industry. Volume contains 13 chapters covering gas, arc, and resistance welding processes, with a chapter on standard welding symbols; some 845 illustrations and about 100 tables are included. A chapter is devoted to the details of each process, or group of related processes, and each group is followed by a chapter on applicable equipment. Each chapter is provided with a separate bibliography.

HOW TO INCREASE YOUR CREATIVE OUTPUT — A GUIDE FOR THE ENGINEER AND SCIENTIST. Deutsch & Shea Inc. Industrial Relations News, 1959, 22 pp. $1.50. Practical guideposts for increasing creative output. Guides distilled from a study of methods used by many acknowledged creative scientists, engineers, and other creative individuals. Two basic creativity checklists are included for engineers, to suggest avenues for improving products, devices, or machines.

HEALTH-PHYSICS PROCEDURES FOR AN AEROMEDICAL RADIOISTOPES LABORATORY. T. J. McGuire, Aero Medical Lab., Wright Air Development Center, U. S. Air Force. March 1957. 35 pp. Recommended procedures for use by installations and personnel involved in handling radioisotopes. (Order PB 131196. Price: $1.)

METHODS AND PROCEDURES FOR RADIATION DAMAGE ANALYSIS. W. L. Fink, Convair, for the U. S. Air Force. June 1957. 103 pp. Analytical methods by which radiation damage data can be used in aircraft engineering design are outlined systematically. (Order PB 151359. Price: $2.50.)

MATERIALS IN SPACE ENVIRONMENT: Proceedings of the fifth Sagamore Ordnance Materials Research Conference, 1958. (Order PB 151900 from OTS, U. S. Department of Commerce, Washington 25, D. C. 276 pp. Price: $4.00.)

PENETRATION OF GAMMA RAYS FROM ISOTOPIC SOURCES THROUGH ALUMINUM AND CONCRETE. (NBS Technical Note 11), M. J. Berger and L. V. Spencer, National Bureau of Standards, 14 pp. May 1959. (Order PB 151370. Price: $.50.)

PERARYLATED SILANES: A class of stable organic molecule. L. Spialter and C. W. Harris, WADC. The perarylated silanes comprise a class of molecules which contains hundreds of thousands—perhaps millions—of members constructed by combining silicon atoms and aromatic groups into various molecular arrangements. Some types have shown unusually-high resistance to radiation, oxidation, and high temperature (to 600 deg C).

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PLASTICS—POLYMER RESEARCH (5-year bibliography): Publication is the first of a series of OTS Selective Bibliographies which will replace catalogs of Technical Reports. New bibliographies are more comprehensive. (Order SB-400, from OTS, U. S. Department of Commerce, Washington 25, D. C. Price: 10 cents.)

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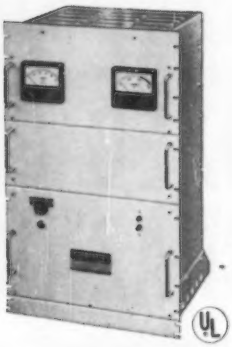

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Research and Development Conference
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Roosevelt Hotel, N. Y., N. Y.

January 25-28
28th Annual Meeting
Institute of the Aeronautical Sciences
Hotel Astor, N. Y., N. Y.

January 28-29
Solid Propellants Conference
American Rocket Society
Princeton University, Princeton, N. J.

February 1-4
Winter Conference & Exhibit
Instrument Society of America
Rice Hotel and Sam Houston Coliseum, Houston, Texas

February 3-4
Sixth Annual Midwest Welding Conference
Armour Research Foundation; Chicago Section, American Welding Society
Illinois Tech Chemistry Bldg., Chicago

February 3-5
1960 Winter Convention on Military Electronics
Institute of Radio Engineers
Biltmore Hotel, Los Angeles

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For the following numbers pertaining to recruitment please use home address.

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241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260

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Alphabetical List of Items

90 **Buyers' Guide, electronic**
Radio Shack Corp.

91 **Catalog, pneumatic vacuum**
Lenz Co.

92 **Electronic Components**
Corning Glass Works

93 **Glass Fabrics**
Coast Mfg. & Supply

94 **Electronic Circuits, packaged**
Centralab
Div. of Globe-Union Inc

95 **Speed Reducers**
The Ohio Gear Co.

96 **Fasteners**
Western Sky Industries

97 **CT-58**
General Electric Co.

98 **Honeycomb, aluminum**
Hexcel Products Inc.

99 **Control Systems**
Minatron Corp.

100 **Clutches, electromagnetic**
I-T-E Circuit Breaker Co.

101 **Research, electronics**
Space Electronics Corp.

102 **Facilities, U. S. I.**
U. S. Industries

103 **Gaskets**
The Advanced Products Co.

104 **Spectrum Analyzers**
Panoramic Radio Products

105 **Relays, time delay**
Tempo Instrument Inc.

106 **Processing, metal surface**
Ransohoff Co.

107 **Meters**
Helipot Div.
Beckman Instruments

108 **Photoconductors**
Eastman Kodak Co.

109 **Fasteners**
Aircraft-Missile Div.
Standard Pressed Steel Co.

110 **Breadboarding**
Gap Instrument Corp.

111 **Measurements, automatic**
Chicago Div.
American Bosch Arma Corp.

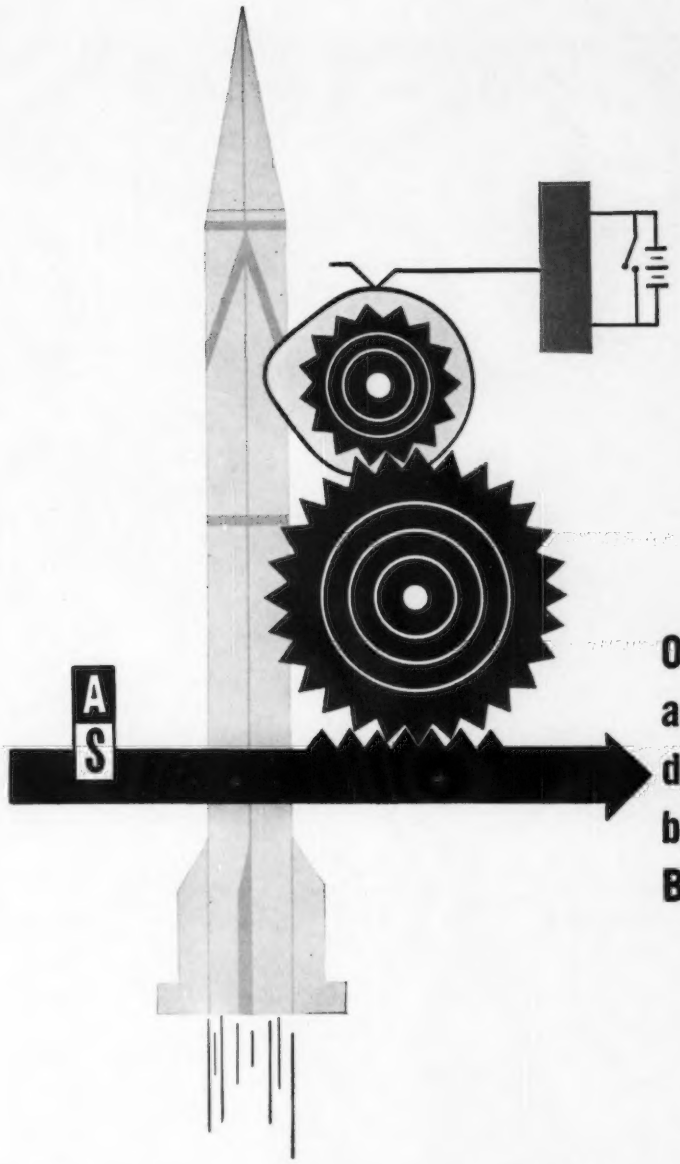
112 **Gamma Radiography**
Nuclear Systems Div.
The Budd Co.

113 **Axial Piston, 5000 psi**
Aero Hydraulics Div.
Vickers Inc.

114 **Valves, air control**
Hannifin Co.

115 **Kellers, numeric**
Pratt & Whitney Co.

116 **Valves & Fittings**
High Pressure Equipment Co.



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